PEYSANJ User's Manual (Novo Tech Software Ltd)

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1. Peysanj

About

PEYSANJ is a bundle of powerful geotechnical tools for bearing capacity, soil liquefaction, pressure meter test, etc designed and developed by Novo Tech Software Ltd. For more information please visit our website.

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YOU ACKNOWLEDGE THAT YOU HAVE READ THIS AGREEMENT, UNDERSTAND IT AND AGREE TO BE BOUND BY ITS TERMS AND CONDITIONS.

3. Contents

3.1 General Tips and Tricks

We recommend minimum 1024*768 screen resolution for using PEYSANJ.

If you are using the dongle key version, please make sure that it is plugged in before you run the program.

To invoke the help, please press button on top-right corner of each page.

Make sure you prepare backup from your data periodically. Your database is the **PEYSANJ4.MDB** file (see more(See 3.10)).

After each installation, please open the "Options" page and set the default parameters and choose your favourite analyses methods. This is a very important step in PEYSANJ installation and setup, otherwise you may end up with incorrect results.

You can print, zoom, set the scales and do more with charts. To activate a chart, simply double-click on it. A new dialog will appear which allows you to configure the look of the chart as well as saving the chart as image files, printing the graph, etc.

Please contact us at support@novotechsoftware.com if you had any questions or suggestions.

How to use the main toolbar(See 3.4)
Working with graphs(See 3.4)
Print preview page features(See 3.8)

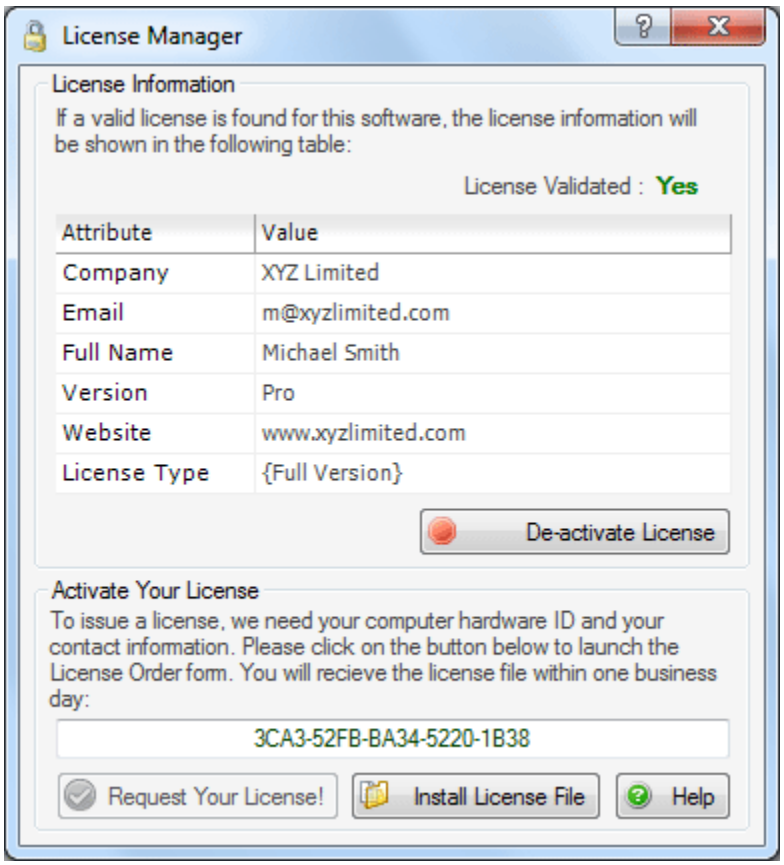
3.2 How to Change Units System?

Peysanj supports both Metric and English unit systems. In order to set the units system, select the **Tools** tab from the top toolbar and click on **Units System** button. A new page will popup; choose the units from the list located at the bottom of the page (see more(See 3.10)).

How to use the main toolbar(See 3.4)
Working with graphs(See 3.4)
Print preview page features(See 3.8)

3.3 Your License Info.

The information you provided to us during your purchase, will be stored in your License File and is used in report headers (top of each page / first page). You can check your License information by clicking on Help ▸ License Manager menu as shown below:



If you have purchased the software but not yet received a license file from Novo Tech, please click on Request Your License! button and follow the instructions to request a license file. When you receive the license file (*.license), please click on Install License File button on this dialog to load and activate the license (program simply copies the license file into the installation folder, you can do this manually as well).

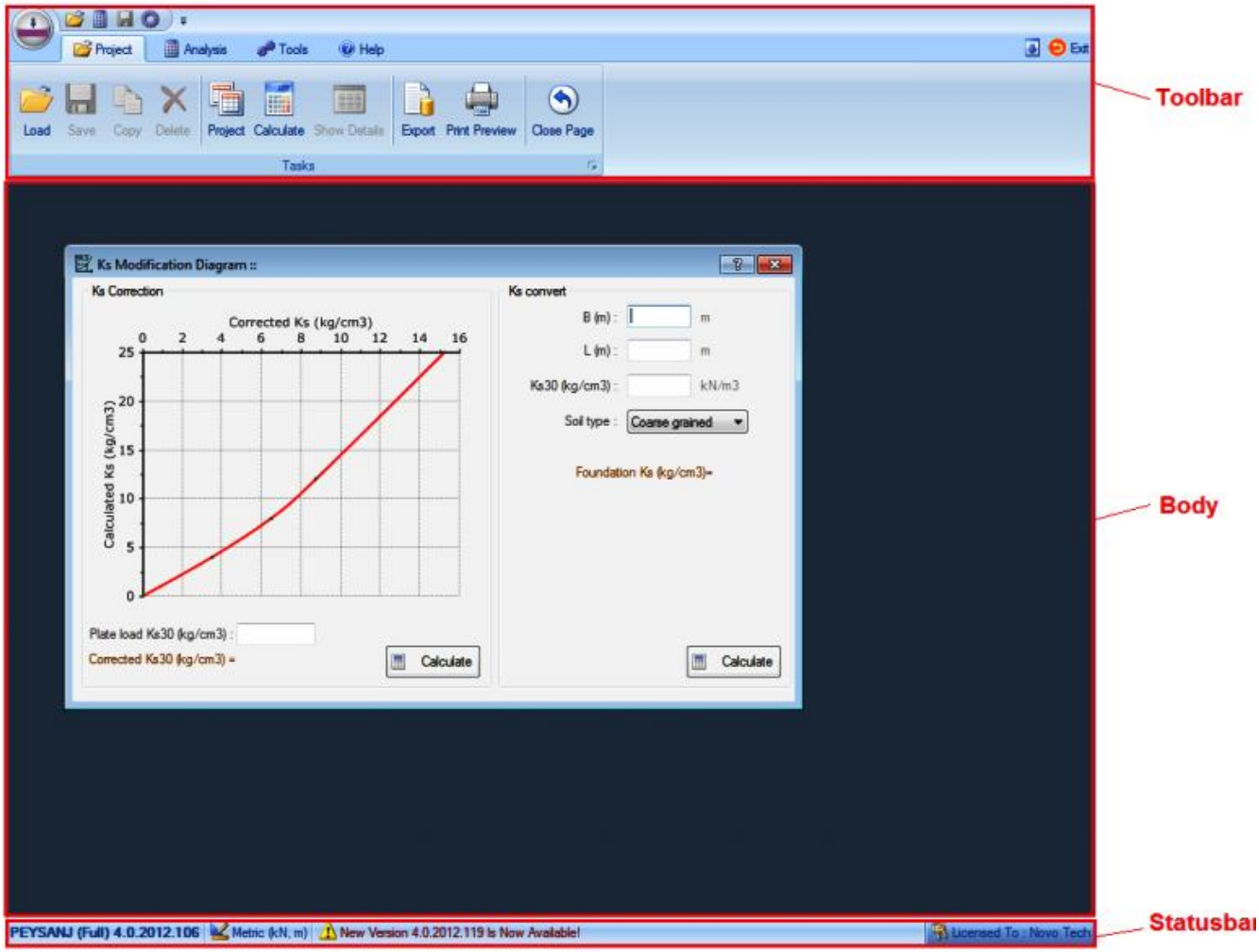
You can also use this dialog to De-activate your license (in case of license transfer).

- How to use the main toolbar(See 3.4)
- Working with graphs(See 3.4)
- Print preview page features(See 3.8)

3.4 Peysanj Main Screen

This is the main page of PEYSANJ and provides so many features through menus and toolbars.

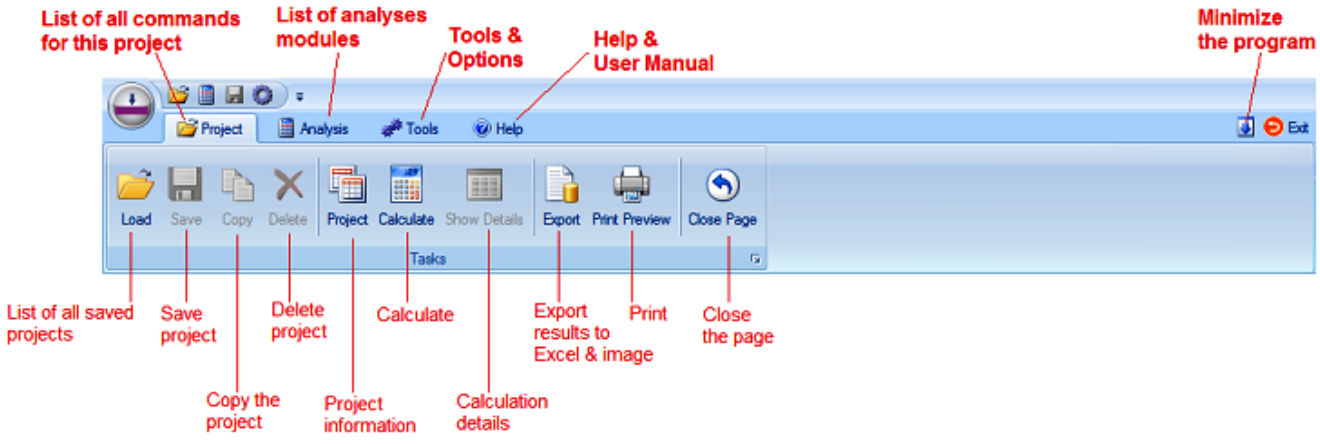
Each part of this page is illustrated below:



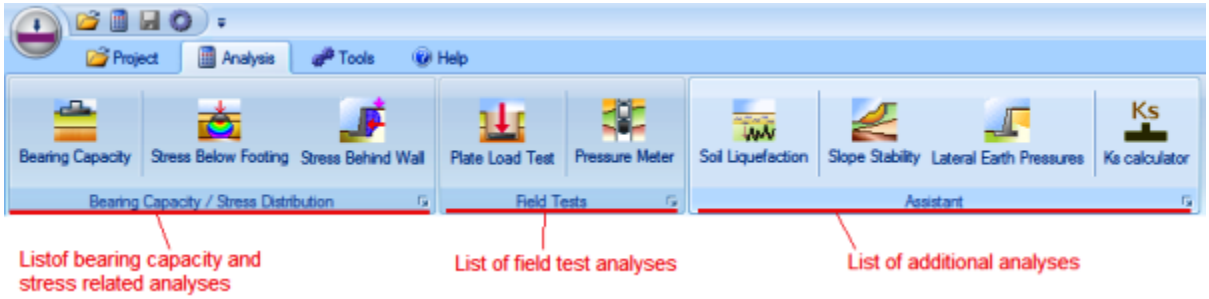
Toolbar (Ribbon)

The toolbar provides you the access to load/save projects, performing the calculations, accessing the help file, etc. Different tabs are illustrated in the following sections:

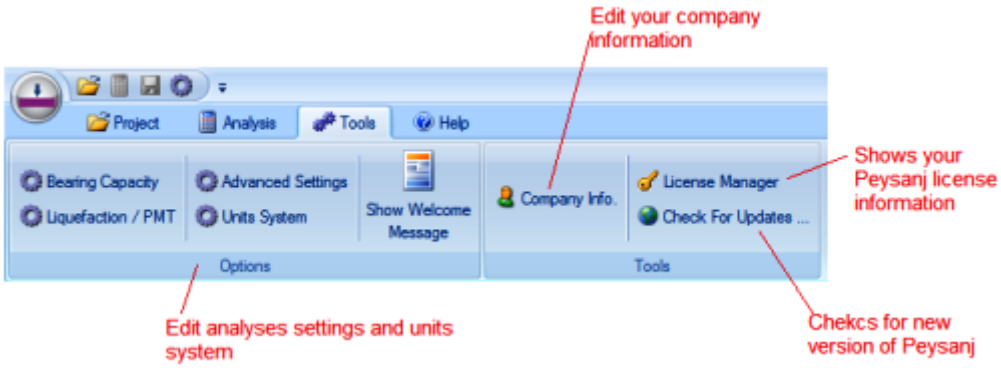
Project tab



Analysis tab



Tools tab

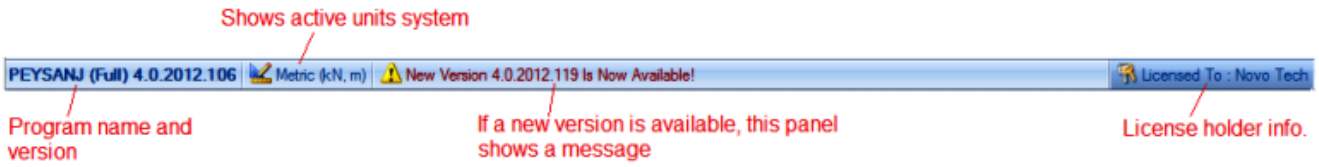


Body

Most of the PEYSANJ analyses are opened in this part of the page. Multiple pages can be opened in this part of the screen.

Statusbar

This partof the screen provides you more information about the license and selected units system. In addition if a new version of Peysanj is available, a message will be shown in the middle panel.


Shows active units system
PEYSANJ (Full) 4.0.2012.106
Metric (kN, m)
New Version 4.0.2012.119 Is Now Available!
Licensed To : Novo Tech
Program name and version
If a new version is available, this panel shows a message
License holder info.

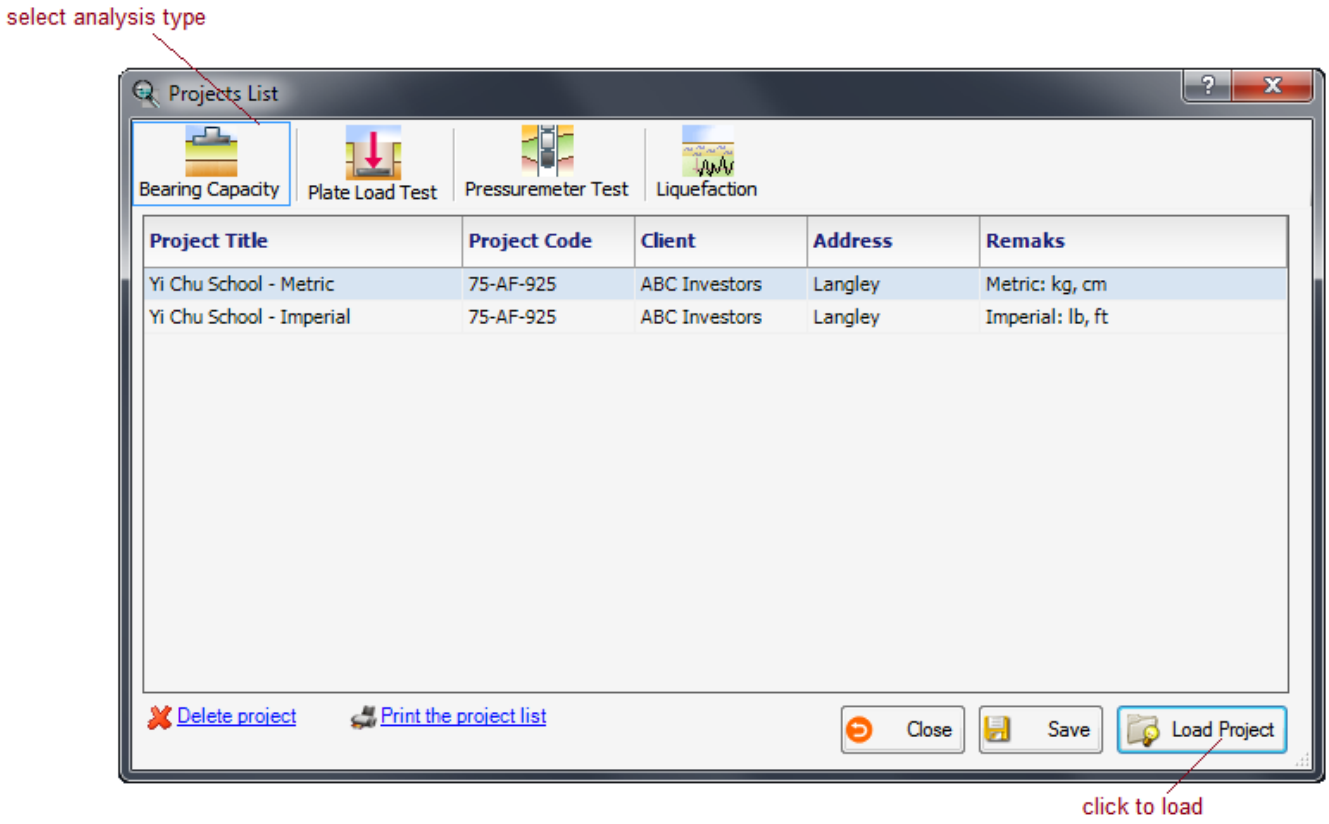
How to use the main toolbar

Working with graphs

Print preview page features(See 3.8)

3.5 Project List

This page can be accessed from the Project » Load toolbar button, and lists all the projects saved in the PEYSANJ database:



In order to load a project, first select the type of analysis (Bearing Capacity, Plate Load Test, etc) from the toolbar. Then simply select the project on the table and click on "Load Project" button. If any of the project's information such as client name or address is edited, click on Save button to store the information.

Deleting a Project

In orderto delete a project along with all its corresponding data click on Delete Project link on the bottom-left portion of the page. Please notice that this action can not be reverted.

How to use the main toolbar(See 3.4)

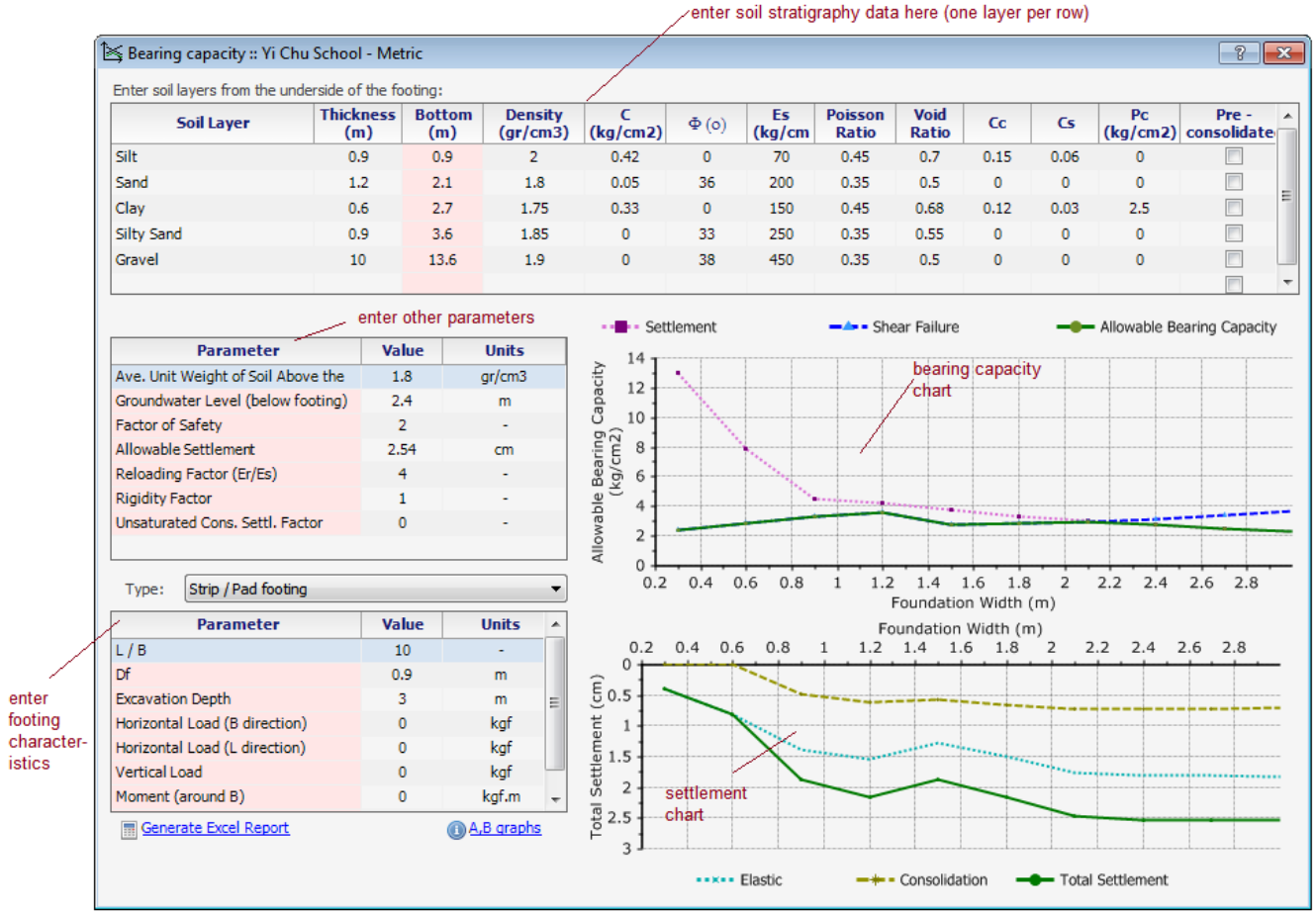
Working with graphs(See 3.4)

Print preview page features(See 3.8)

3.6 Engineering Analysis

3.6.1 Bearing Capacity

This module is used to calculate allowable bearing capacity of shallow foundations with simultaneously checking both shear failure and settlement. Each part of this page is explained below.


enter soil stratigraphy data here (one layer per row)
Bearing capacity :: Yi Chu School - Metric
Enter soil layers from the underside of the footing:
Soil Layer | Thickness (m) | Bottom (m) | Density (gr/cm3) | C (kg/cm2) | Φ (o) | Es (kg/cm | Poisson Ratio | Void Ratio | Cc | Cs | Pc (kg/cm2) | Pre - consolidate
Silt 0.9 0.9 2 0.42 0 70 0.45 0.7 0.15 0.06 0
Sand 1.2 2.1 1.8 0.05 36 200 0.35 0.5 0 0 0
Clay 0.6 2.7 1.75 0.33 0 150 0.45 0.68 0.12 0.03 2.5
Silty Sand 0.9 3.6 1.85 0 33 250 0.35 0.55 0 0 0
Gravel 10 13.6 1.9 0 38 450 0.35 0.5 0 0 0
enter other parameters
Parameter | Value | Units
Ave. Unit Weight of Soil Above the | 1.8 | gr/cm3
Groundwater Level (below footing) | 2.4 | m
Factor of Safety | 2 | -
Allowable Settlement | 2.54 | cm
Reloading Factor (Er/Es) | 4 | -
Rigidity Factor | 1 | -
Unsaturated Cons. Settl. Factor | 0 | -
Type: Strip / Pad footing
enter footing character-istics
Parameter | Value | Units
L / B | 10 | -
Df | 0.9 | m
Excavation Depth | 3 | m
Horizontal Load (B direction) | 0 | kgf
Horizontal Load (L direction) | 0 | kgf
Vertical Load | 0 | kgf
Moment (around B) | 0 | kgf.m
Generate Excel Report
A,B graphs
Settlement
Shear Failure
Allowable Bearing Capacity
bearing capacity chart
Allowable Bearing Capacity (kg/cm2)
Foundation Width (m)
Foundation Width (m)
settlement chart
Total Settlement (cm)
Elastic
Consolidation
Total Settlement

Project Information

Please enter project title, client name, project code, etc. This data will be shown on your reports.

Soil Layers Table

Your stratigraphy model may contain unlimited soil layers. Please specify the following parameters for each layer:

- **Soil Layer:** simple description for layer. This field is only for user's information and does not have any effect on bearing capacity analysis
- **C (kg/cm2):** Coefficient of cohesion

- **F (deg):** Internal angle of friction (between zero and 45 degrees)
- **Es (kg/cm2):** Modulus of elasticity
- **v:** Poisson ratio (between zero and 0.5)
- **g (gr/cm^3):** Wet unit weight
- **Z1 (m):** top depth of the layer
- **Z2 (m):** bottom depth of the layer. There should be no gap between layers, so Z1 for this layer should be same as Z2 for layer above. For the last layer use a very large number like 1000m to assure that stress bulb would not pass the bottom of your model.
- **Su (kg/cm2):** Undrained shear strength. This parameter should only be entered when F=0; based on Hanson bearing capacity theory, when F=0 then Su will be considered for shear failure analysis.
- **Cc , Cs:** Consolidation compression and re-compression indexes. They should only be entered when you want the consolidation settlement to be calculated for this layer. If these parameters are entered but water level is below this layer, unsaturated consolidation settlement will be calculated for this layer ($Su_{unsaturated}=Su_{saturated}*a$ where a is a factor less than one). You may specify a in "Analysis Parameters" frame.
- **Pc (kg/cm2):** Pre-consolidation stress for consolidation settlement
- **eo:** Void ratio
- **Pre-consolidated:** Only select this option if your layer is pre consolidated

To delete a layer, click on row-header to select the whole row, and then press DELETE key on your keyboard.

If there is a bedrock in your model, only enter soil layers, when program computes the stress bulbs, no settlement will be calculated beyond the defined soil layers.

It is recommended to press Save button on toolbar right after you entered the data. Then close the form and re-open it from Projects page.

In this section, ground water level and wet unit weight for soil above the foundation level should be specified. Please notice that ground water level is measured from underneath the footing (always positive number).

Analysis Settings

This section contains parameters which are very important for bearing capacity analysis:

- **Allowable Settlement (cm):** this amount is usually one inch (25.4mm) for pad/strip footings.
- **Er/Es:** is the ratio of modulus of elasticity of re-loading (Er) to loading (Es) part. The best way to estimate the Er is to use the Plate Loading Test; at the beginning of second cycle of this test, the slope of the stress-deformation curve (Er) is comparatively sharper than

normal slope of the curve (Es). PEYSANJ uses this Er/Es ratio to apply the stress history effect on the elastic settlement. For example if your footing Df=1m and g=2gr/cm3 then gDf~0.2kg/cm2 so during elastic settlement analysis, PEYSANJ will use Er for stress range 0 to 0.2 kg/cm2 and thereafter Es is used for analysis.

- **Rigidity Factor (Ir):** This factor is less than zero and depends on rigidity of the footing (usually 0.9 to 1). PEYSANJ applies this factor to total settlement: S=(Se+Sc)*Ir where Se and Sc are elastic and consolidation settlements, respectively.
- α **Factor**: this factor is used for calculation of un-saturated consolidation settlement. If a fine-grained layer is unsaturated (e.g. S=80%), then the actual consolidation settlement is a fraction of calculated saturated consolidation settlement. Please specify this parameter (between zero and unity).
- **Safety Factor:** this parameter is applied to shear failure of the soil below the footing.

Foundation Size

- **Shape:** you may choose among "Pad/Strip", "Raft/Spread" and "Circular" foundations.
- **Size ratio (L/B):** is used to specify the length to width ratio of the footing.
- **Df :** is the height of the soil around and above the footing (affects the shear failure)
- **D :** depth of placement of the foundation (usually depth of excavation).
- **MB, ML:** The bending moment applied on the footing
- **HB, HL:** The horizontal forces applied to the footing
- **V :** The vertical force applied on the footing

Note : for raft footings consider Df and D the same as excavation depth.

How to see the calculation results?

Please press Calculate button on the toolbar when you entered all input parameters. Then click on each tab to see the corresponding chart. By clicking on each chart, more options will be available including export to Excel and image formats.

Pad/Strip footings outputs

For this type of footings, two charts are provided:

Bearing Capacity chart

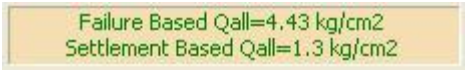
Includes 3 curves; for all of them vertical axis is the allowable stress and horizontal axis is the foundation width (B); please note that, you have already entered L/B ratio so as B increases, the chart covers various foundation sizes:

- **Shear Failure Curve (blue):** Only encompasses the shear failure criteria for the model.
- **Allowable Settlement Curve (purple):** This curve shows the allowable stress, provided that the total settlement is around the allowable settlement already introduced by the user.

- **Allowable Bearing Capacity Curve (green):** This curve is the lower intersection of two above-mentioned curves and assures that on each point along the curve, both settlement and shear failures are within the allowable limits.

Settlement chart: includes 3 curves representing Immediate (elastic), Consolidation and Total settlements. Please be advised that these settlement values are calculated based on allowable bearing capacity calculated for that specific footing.

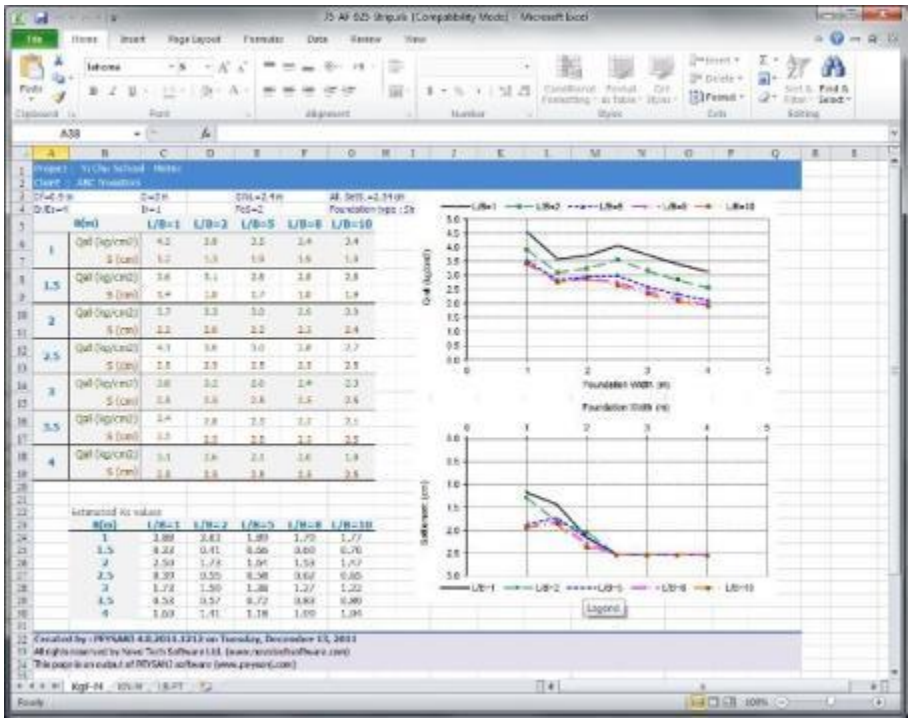
Raft foundations output



For raft foundations since the size is considerable, shear failure is not usually an issue and restricting the settlement to allowable amount, controls the allowable bearing capacity. Based on user-defined allowable settlement for this footing, the corresponding allowable stress is picked from the settlement plot and is shown on a box.

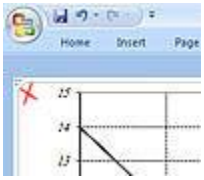
Exporting the results to Excel

Click on the Excel tab in the bearing capacity page. This will generate an Excel file containing all Allowable bearing capacity and settlement values for various L/B ratios and different foundation widths (B). The width range and L/B ratios can be specified in the Option page.



1. To generate the Excel file, please click on "Export to Excel" button on Excel tab. This will take few minutes to prepare the file. Please be patient.

2. When you prompt to open the Excel file, please select Yes. When Excel opens the file click on the tabs below the page to view the charts or calculation summary.
3. You can easily copy and past all charts into your other Windows applications (such as Word). please click on top-left corner of charts and right-click. Then choose Copy from the popup menu. Now you just need to paste the chart into your destination program (such as Word).



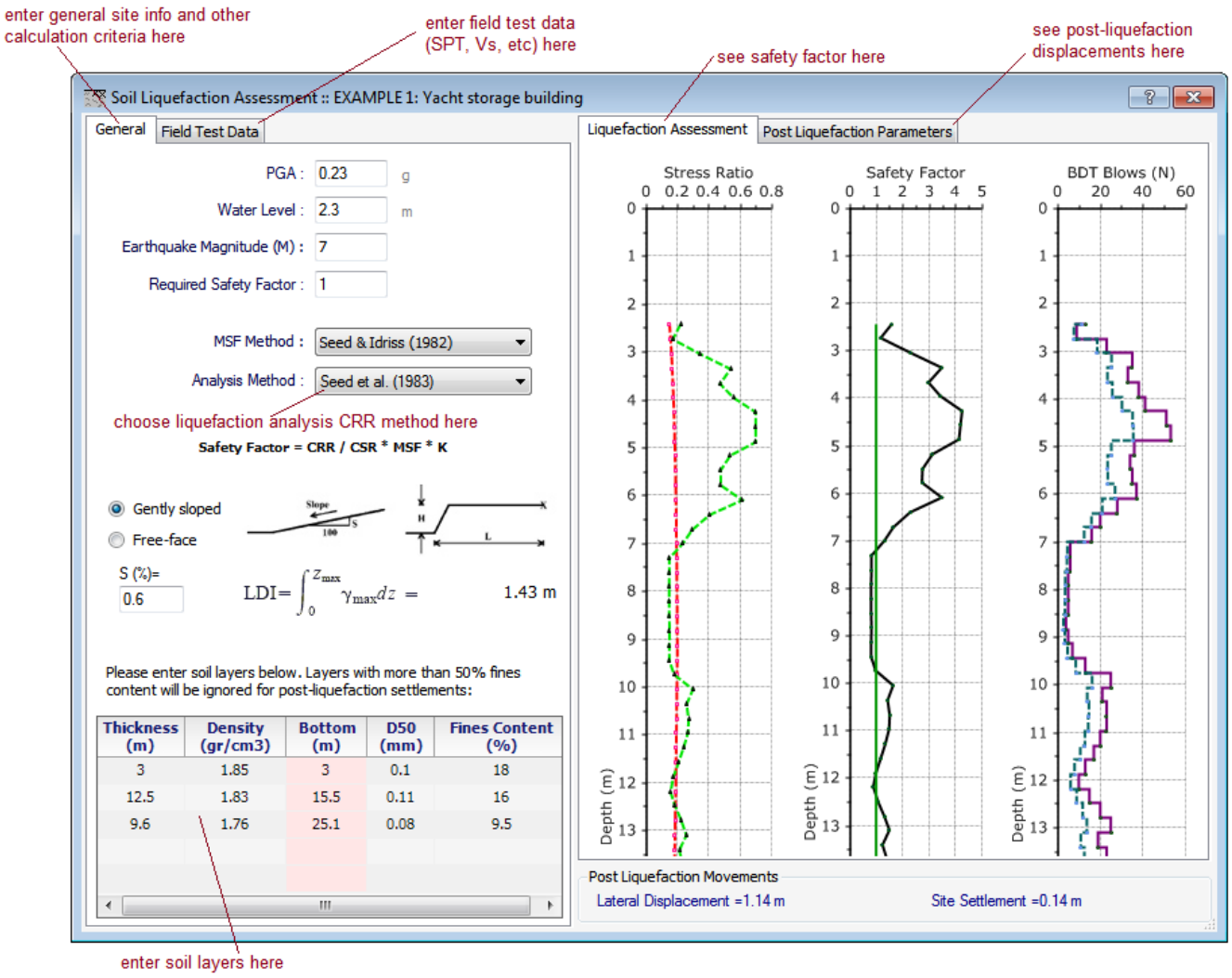
Printing the results

Press Print button from the toolbar to see the calculation details and the report.

How to use the main toolbar(See 3.4)
Working with graphs(See 3.4)
Print preview page features(See 3.8)

3.6.2 Soil Liquefaction

This module is used to calculate safety factor against soil liquefaction along with estimated post-liquefaction displacements and residual strength. As illustrated below, please enter site data, liquefaction triggering criteria and field test data, then click on Calculate button from the top toolbar. The results will be shown on the right side of the page in the form of various plots.


enter general site info and other calculation criteria here
enter field test data (SPT, Vs, etc) here
see safety factor here
see post-liquefaction displacements here
Soil Liquefaction Assessment :: EXAMPLE 1: Yacht storage building
General
Field Test Data
Liquefaction Assessment
Post Liquefaction Parameters
PGA : 0.23 g
Water Level : 2.3 m
Earthquake Magnitude (M) : 7
Required Safety Factor : 1
MSF Method : Seed & Idriss (1982)
Analysis Method : Seed et al. (1983)
choose liquefaction analysis CRR method here
Safety Factor = CRR / CSR * MSF * K
Gently sloped
Free-face
S (%)= 0.6
LDI= 1.43 m
Please enter soil layers below. Layers with more than 50% fines content will be ignored for post-liquefaction settlements:
Thickness (m) | Density (gr/cm3) | Bottom (m) | D50 (mm) | Fines Content (%)
3 | 1.85 | 3 | 0.1 | 18
12.5 | 1.83 | 15.5 | 0.11 | 16
9.6 | 1.76 | 25.1 | 0.08 | 9.5
Stress Ratio
Safety Factor
BDT Blows (N)
Depth (m)
Post Liquefaction Movements
Lateral Displacement =1.14 m
Site Settlement =0.14 m
enter soil layers here

Printing the results

Press Print button from the toolbar to see the calculation details and the report.

The graphs

In order to obtain the details of stress values at each depth, simply double click on the chart (more(See 3.9)).

- How to use the main toolbar(See 3.4)
- Working with graphs(See 3.4)
- Print preview page features(See 3.8)

3.6.3 Plate Loading Test

This page is designed for calculating plate loading test. Please enter all 3 settlement gauge readings and press Calculate button from the top toolbar. Modulus of subgrade reaction for each cycle of loading-unloading will be calculated separately and will be presented in the table.

Printing the results

Press Print button from the toolbar to see the calculation details and the report.

How to use the main toolbar(See 3.4)
Working with graphs(See 3.4)
Print preview page features(See 3.8)

3.6.4 Pressure-meter Test

This page is designed for calculating pressure meter test. Please enter calibration data and test data (including pressure and volume pairs); then press Calculate button from the top toolbar. Menard modulus (Em) and limit pressure (Pl) will be calculated and presented in the table.

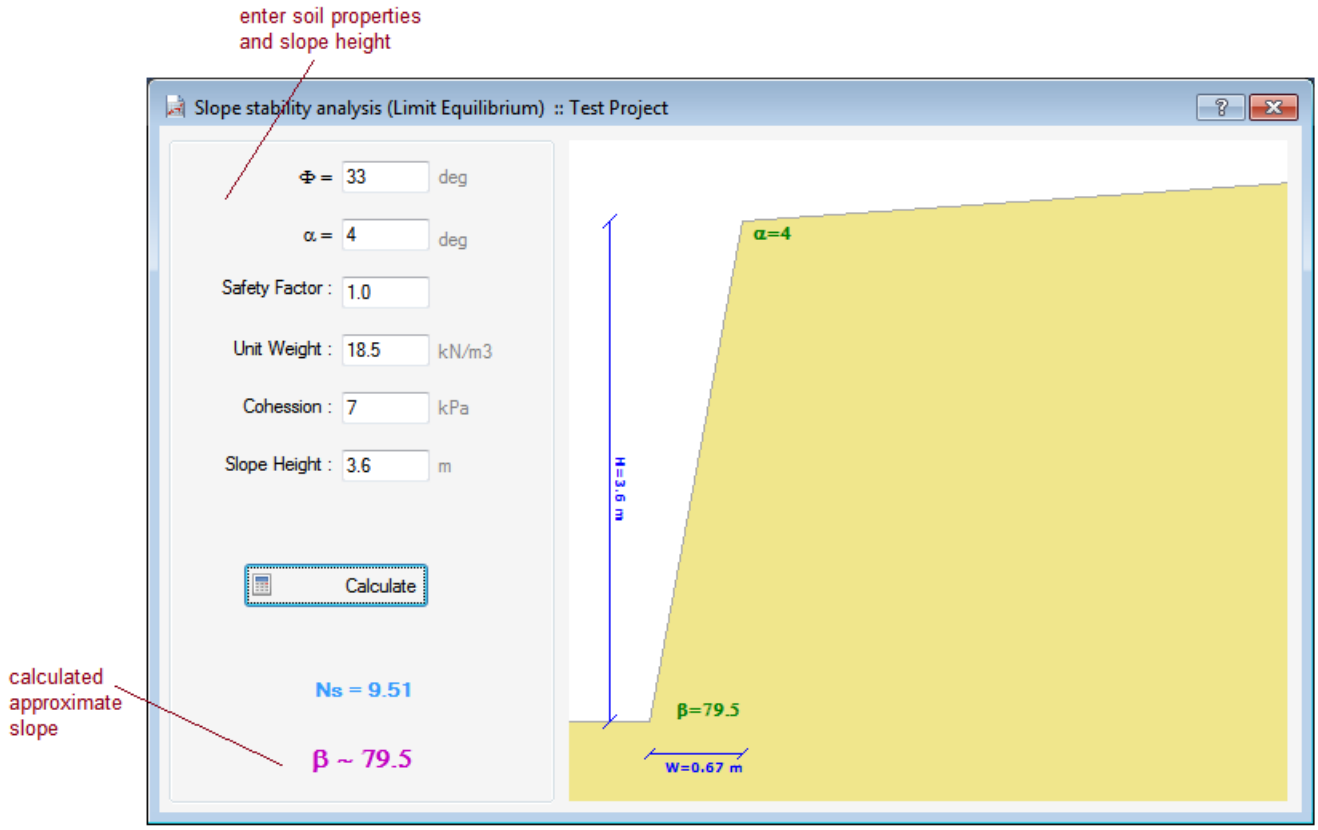
Printing the results

Press Print button from the toolbar to see the calculation details and the report.

How to use the main toolbar(See 3.4)
Working with graphs(See 3.4)
Print preview page features(See 3.8)

3.6.5 Slope Stability

Using this page user can roughly estimate the stable slope based on the design table proposed by Fang. This table is calculated based on limit equilibrium analysis and should be only used as a rough estimate since it does not many parameters such as groundwter level, surchage, etc.

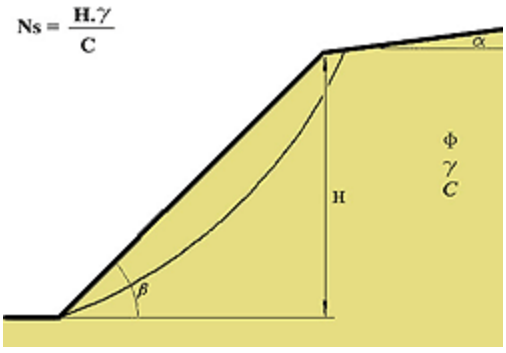


Soil and Slope Parameters

Enter soil friction angle, unit weight and cohesion along with slope height and backslope angle. Please notice that safety factor will be applied on Tan(Φ). Press Calculate button when all fields entered.

Stability Factor and β

Ns or stability factor is calculated based on slope height (H), soil unit weight (γ) and soil cohesion (C) as shown below:

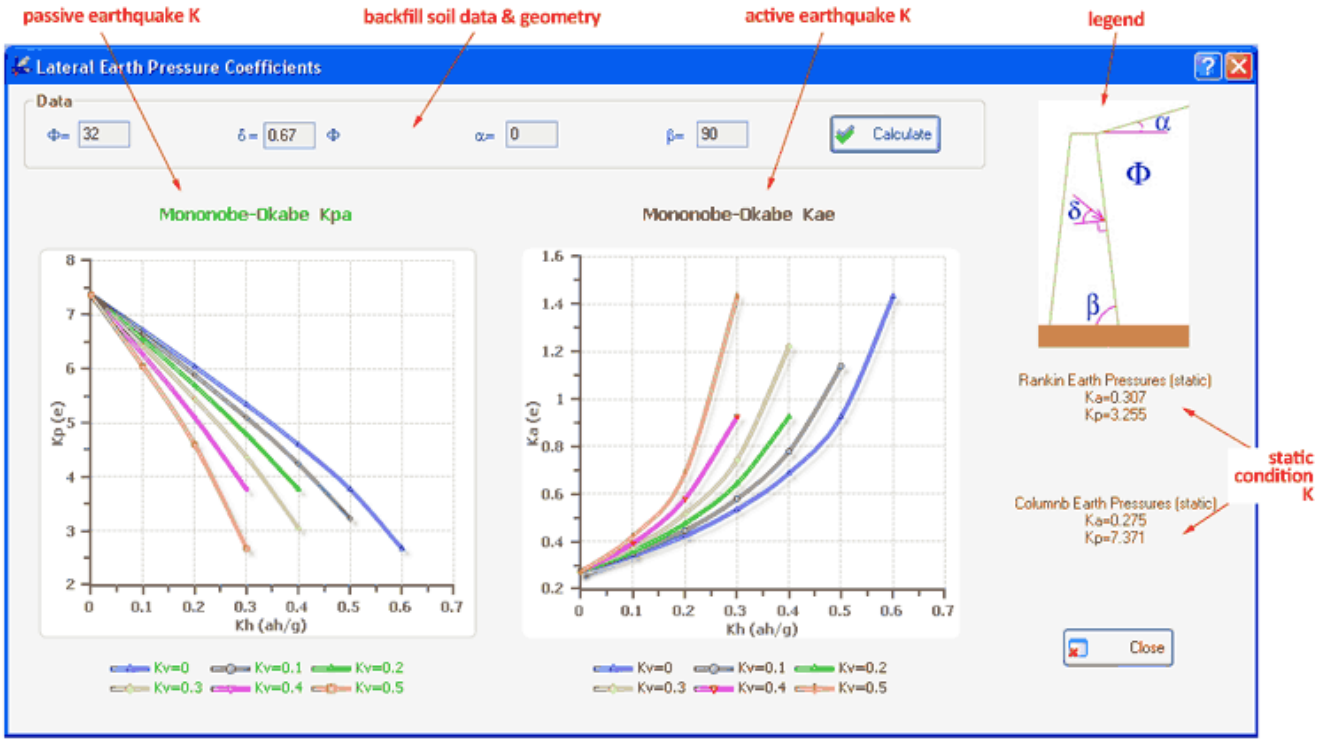


This parameter is a key factor for estimating the stable slope angle, according to this methodology.

How to use the main toolbar(See 3.4)
Working with graphs(See 3.4)
Print preview page features(See 3.8)

3.6.6 Lateral Earth Pressure Coefficients

You can calculate lateral earth pressure coefficients in static and earthquake conditions using this page.



Wall geometry and soil data

Please enter the soil parameters and geometry as specified in the legend and press Calculate button.

Static Conditions	
Earthquake Conditions	Mo Kh and Kv are horizontal and vertical acceleration ratios of the earthquake: Kh=ah/g Kv=av/g Kae : Active earthquake pressure coefficient Kpe : Passive earthquake pressure coefficient

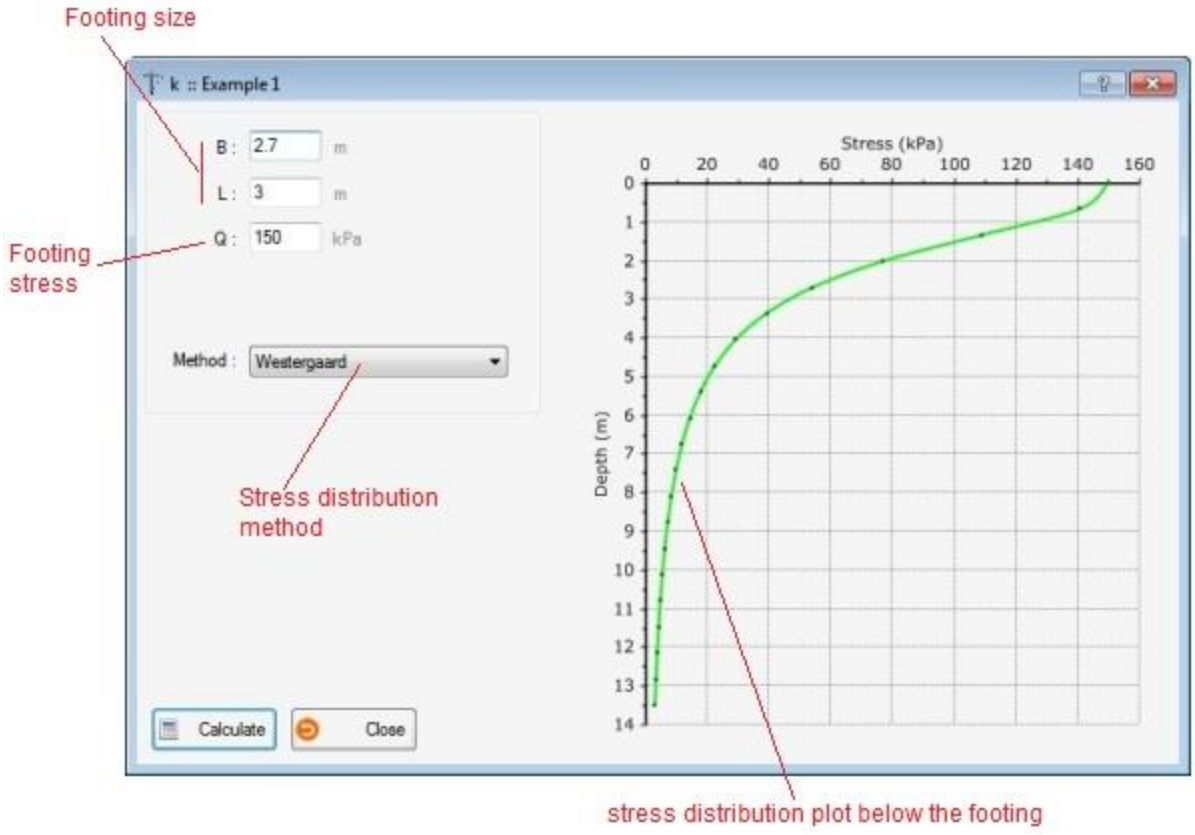
Earthquake Conditions (Mononobe / Okabe) Charts

To use this charts please choose the curve corresponding your Kv. Then find the desired Kh from horizontal axis and follow the curve to get the K values from the vertical axis.

How to use the main toolbar(See 3.4)
Working with graphs(See 3.4)
Print preview page features(See 3.8)

3.6.7 Stress Distribution

Using this page user can plot the distribution of the stress below the footing according to Westerggard or 2:1 Slope methods. The following screenshot illustrates input and output of this module:


Footing size
k :: Example 1
B : 2.7 m
L : 3 m
Q : 150 kPa
Footing stress
Method : Westergaard
Stress distribution method
Calculate
Close
Stress (kPa)
0 20 40 60 80 100 120 140 160
Depth (m)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
stress distribution plot below the footing

Printing the results

Press Print button from the toolbar to see the calculation details and the report.

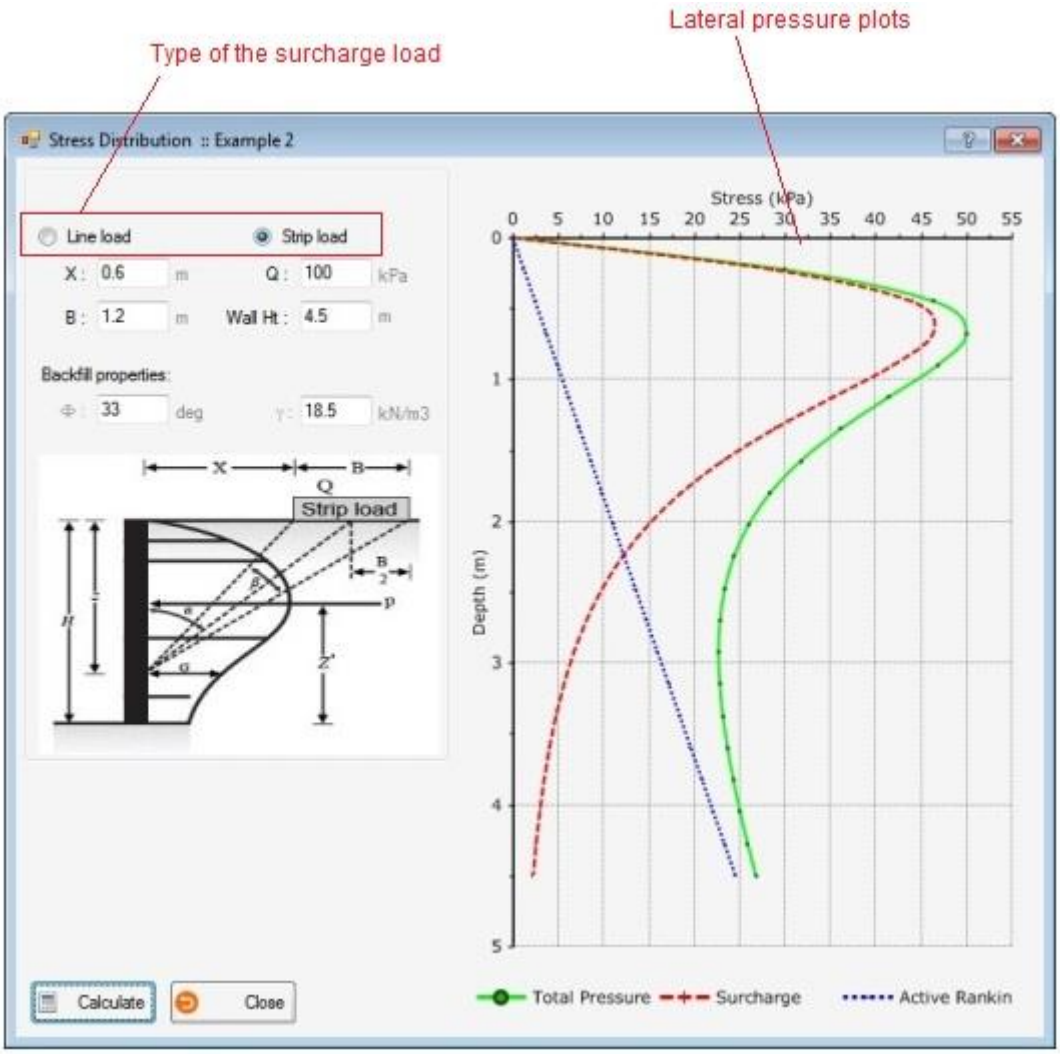
The graph

In order to obtain the details of stress values at each depth, simply double click on the chart (more(See 3.9)).

- How to use the main toolbar(See 3.4)
- Working with graphs(See 3.4)
- Print preview page features(See 3.8)

3.6.8 Retaining Wall Pressure

Using this page user can calcularte the distribution of the lateral earth pressure behind the retaining walls due to the surcharge. This surcharge can be line load or strip load. The following screenshot illustrates input and output of this module:



Printing the results

Press Print button from the toolbar to see the calculation details and the report.

The graph

In order to obtain the details of stress values at each depth, simply double click on the chart (more(See 3.9)).

How to use the main toolbar(See 3.4)

Working with graphs(See 3.4)

Print preview page features(See 3.8)

3.6.9 Ks Conversion

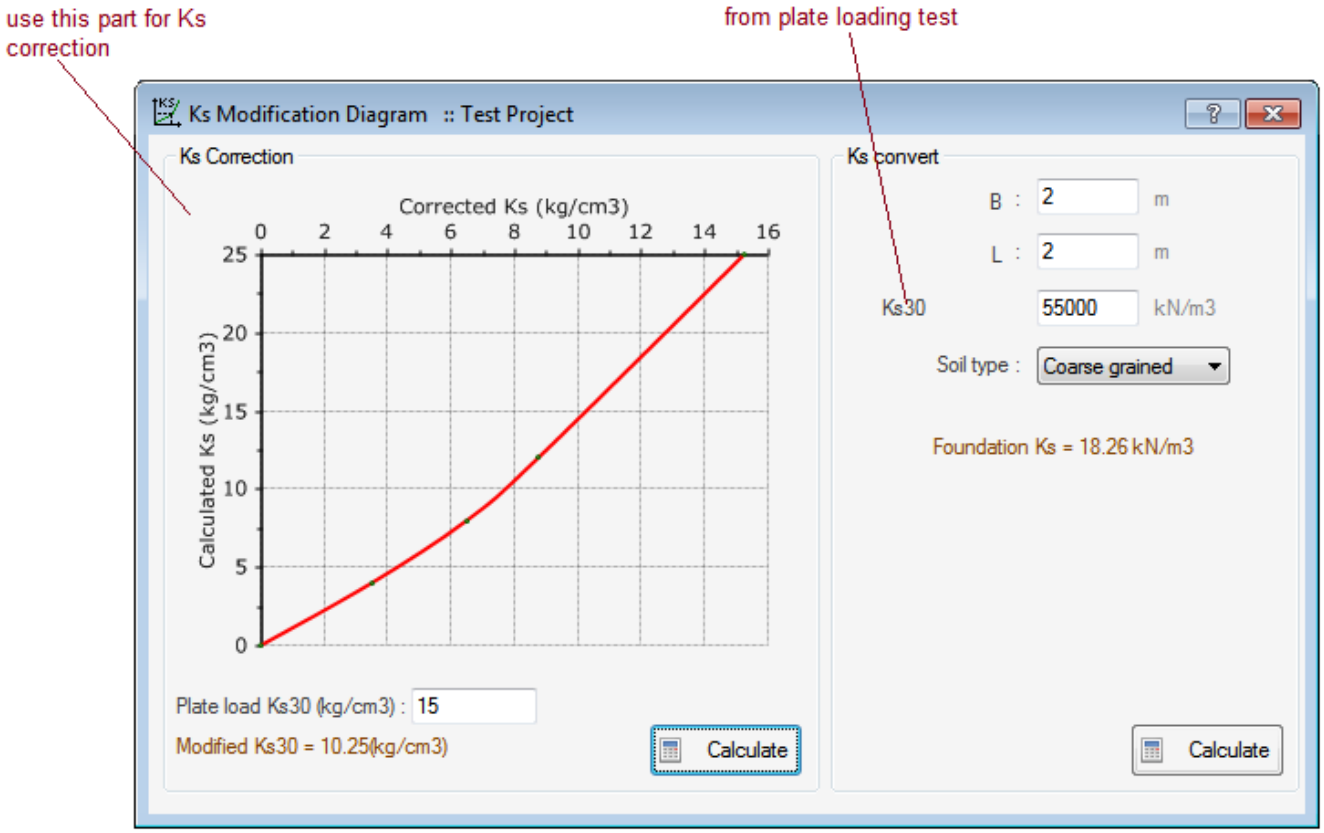
This page is used for conversion and correction of plate load test resulted Ks30. Each tool is separately described below:

Ks Correction

Some geoscientists believe that because of the thickness of plate used in plate loading test, the resulted Ks30 is recommended to be corrected for the stiffness of the plate. The chart shown on the left part of the page can be used for correction of Ks30. Please enter your test Ks30 in the box below the chart and press Calculate button to get the corrected Ks30.

Ks Conversion

This part of the page uses the common formulas for converting Ks30 to your desired footing's size. Different formulas is used according to soil type.


use this part for Ks correction
from plate loading test
Ks Modification Diagram :: Test Project
Ks Correction
Corrected Ks (kg/cm3)
0 2 4 6 8 10 12 14 16
25 20 15 10 5 0
Calculated Ks (kg/cm3)
Plate load Ks30 (kg/cm3) : 15
Modified Ks30 = 10.25(kg/cm3)
Calculate
Ks convert
B : 2 m
L : 2 m
Ks30 55000 kN/m3
Soil type : Coarse grained
Foundation Ks = 18.26 kN/m3
Calculate

How to use the main toolbar(See 3.4)
Working with graphs(See 3.4)
Print preview page features(See 3.8)

3.7 Calculation Details

As a general rule, all calculations in PEYSANJ come with step-by-step calculation details. Please press "Calculation Details" button on toolbar after performing the calculations. This will show another page containing the details. If you desire to print a report, click on "Print" button on the toolbar to open the Print Preview(See 3.8) page. A report comprises:

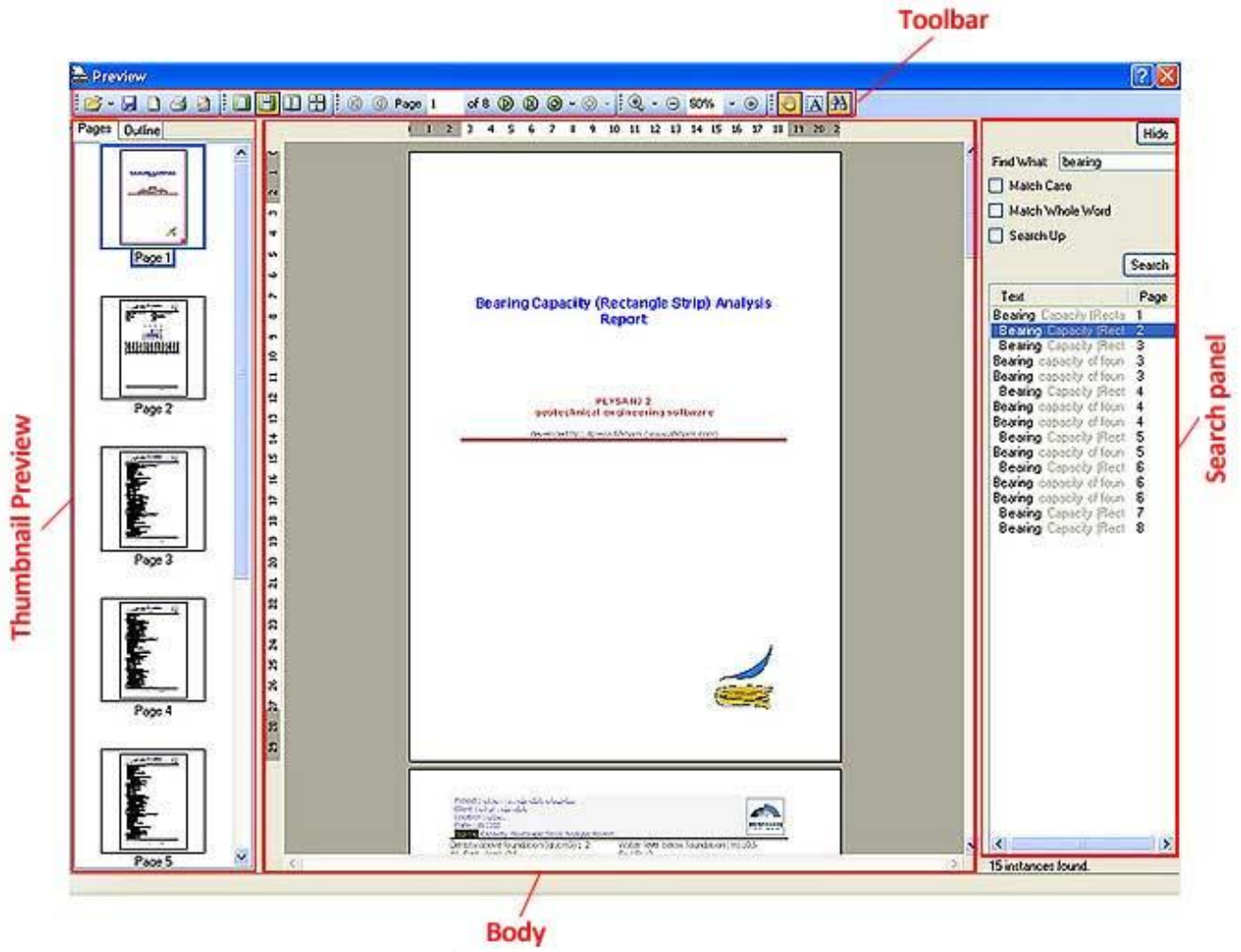
- Cover page
- Assumptions: including all input data and other applicable assumptions
- Details: including step-by-step details of the calculations
- Plots: including all graphs

This report may be saved and exported to various formats such as Microsoft Excel, PDF, etc.

How to use the main toolbar(See 3.4)
Working with graphs(See 3.4)
Print preview page features(See 3.8)

3.8 Print Preview

This page will be shown when you click on Print button from the toolbar. Different parts of the page are described below:



Thumbnail Preview

Shows a set of thumbnails for all pages of the report. Click on each thumbnail to open that page of the report in the Body part of the page.

Body

Is used to show the full preview of the specific page of the report. Please use the toolbar buttons to zoom in/out, save, print, etc

Toolbar

This toolbar located on top of the page and its buttons are described below:

Opens a report file which is already saved under c1d format

Is used to save the current report with XLS, PDF, HTML, or even image formats such as JPG, BMP, TIFF, PNG, etc. Some limitations apply to this feature.

Used to adjust the page setup such as margins, etc.

Click on this button to print the report

This will redraw the whole report again

Sets the view of report by showing 1, 2 and 4 pages of the report within the Body part of the viewer.

Used to navigate among the report pages. Enter the exact page number in the box to jump to that page.

Used for zoom

Used for pan (moving the preview page). Hold your left mouse button and move the page.

If you click on this button, you will be able to select a text within the report. This feature can be used to copy a text from the report for use in another Windows application such as Microsoft Word.

Use this button to find a phrase in the report.

Search Panel

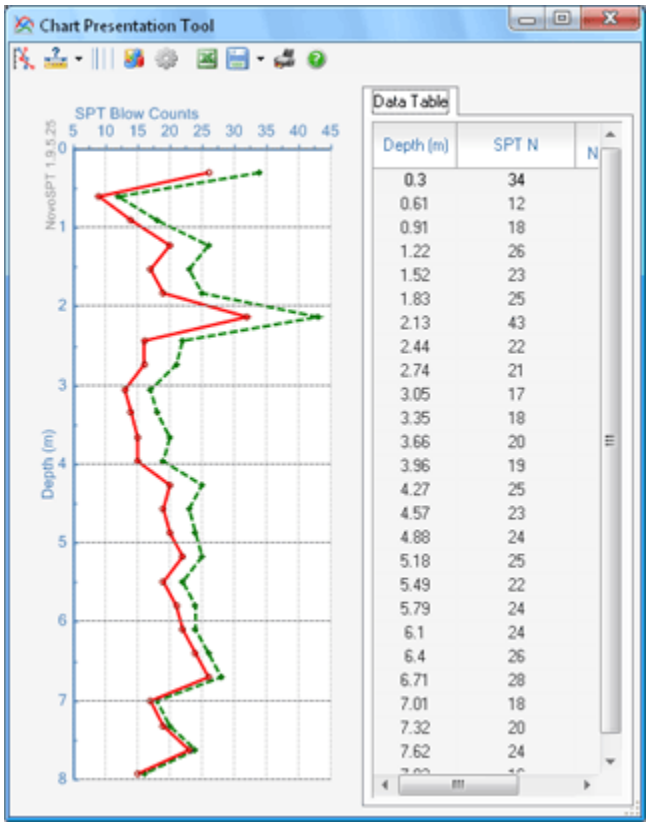
Enter the searching phrase in this panel and click the Search button. A list will be populated with all pages containing your search criteria. Click on each item to browse to that page.

How to use the main toolbar(See 3.4)

Working with graphs(See 3.4)
Print preview page features(See 3.8)

3.9 Working with Graphs

We understand that presentation of the analysis results is very important to our users. Everywhere in Novo Tech Software programs when you click on a chart, a new dialog appears containing the chart and its associated data. In the following example, the corresponding dataset is shown on right and can be scrolled horizontally and vertically to view all data. In addition, toolbar buttons provide you with more features:



To change line styles of the plot

To change the scale (minimum, maximum and gridlines) of each axis. Please click on small arrow on right side of the icon to open the dropdown menu

To toggle between normal/logarithmic scale for horizontal axis

To change the chart type

To open the advanced settings page for the chart

To save the dataset table as Microsoft Excel file

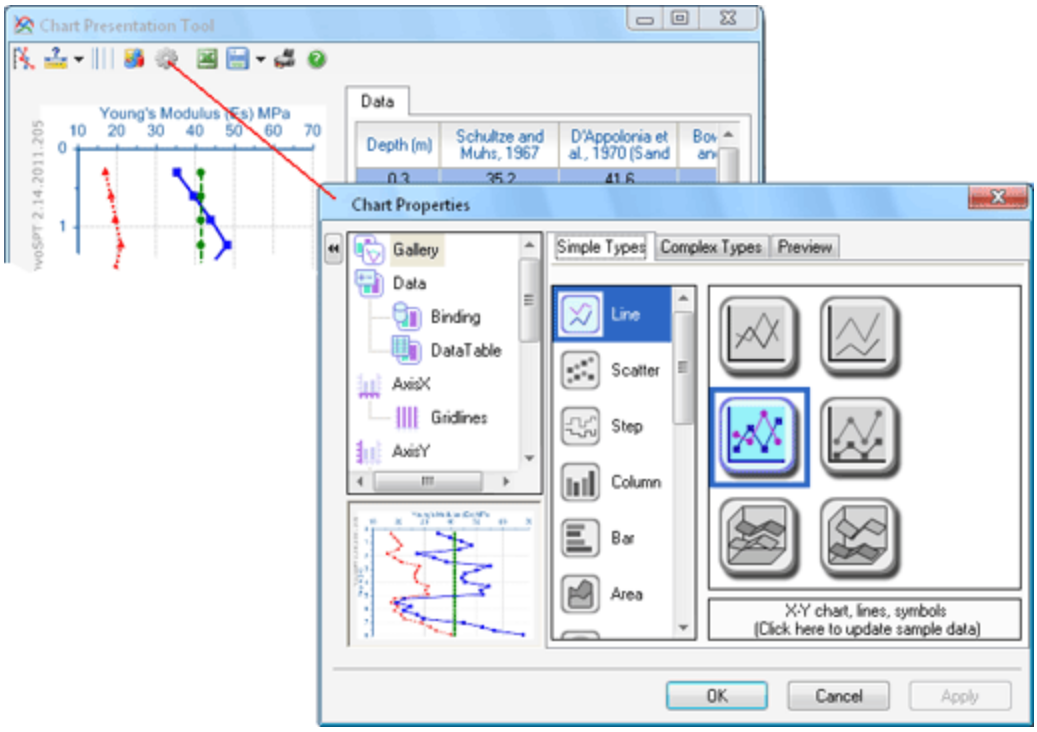
To save the chart as text and graphic format

To print the chart

Opens this help page

How can I change the appearance of the chart such as legend, chart type, etc?

You can configure almost everything in the chart by clicking on button from the toolbar. This will open the following dialog box:



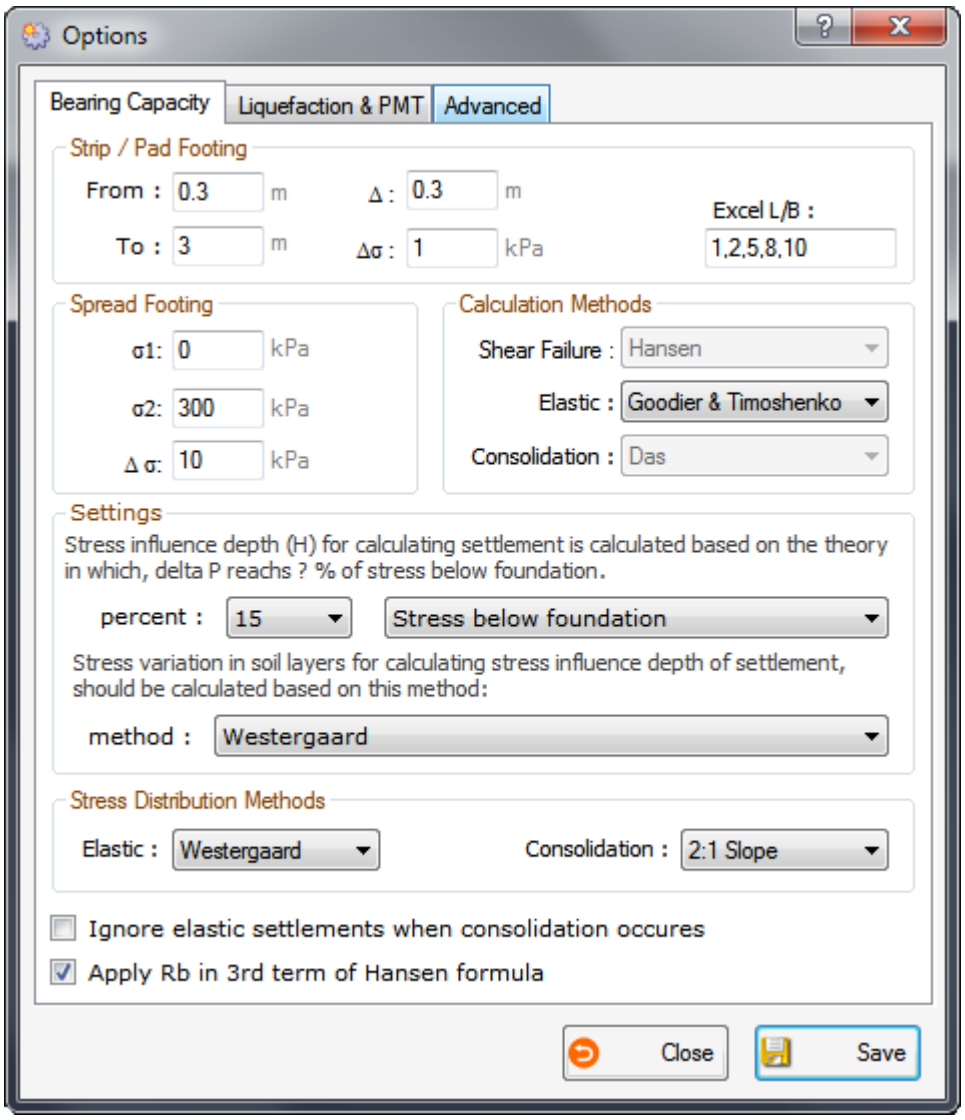
Click on the desired element from the list located on the left side of the page; more options will be shown on the right portion. Click on OK button to apply your changes.

3.10 Options and Settings

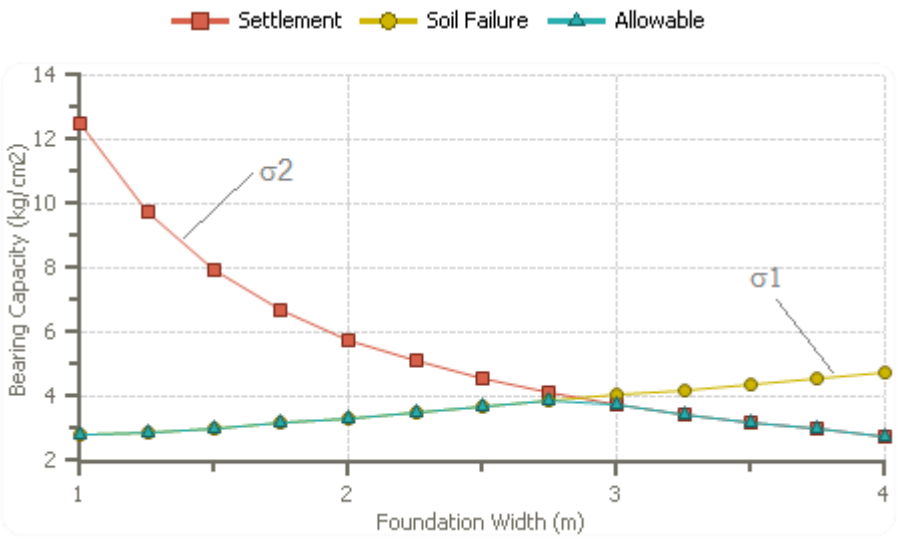
The Options page provides access to analysis settings and default values used during the calculations and analyses. As shown in the following screenshot, settings are grouped into three tabs:

Bearing Capacity tab

This tab allows user defining the analysis methods used for the calculation of bearing and settlement.


Options
Bearing Capacity
Liquefaction & PMT
Advanced
Strip / Pad Footing
From : 0.3 m
To : 3 m
Δ : 0.3 m
Δσ : 1 kPa
Excel L/B :
1,2,5,8,10
Spread Footing
σ1: 0 kPa
σ2: 300 kPa
Δ σ: 10 kPa
Calculation Methods
Shear Failure : Hansen
Elastic : Goodier & Timoshenko
Consolidation : Das
Settings
Stress influence depth (H) for calculating settlement is calculated based on the theory in which, delta P reachs ? % of stress below foundation.
percent : 15
Stress below foundation
Stress variation in soil layers for calculating stress influence depth of settlement, should be calculated based on this method:
method : Westergaard
Stress Distribution Methods
Elastic : Westergaard
Consolidation : 2:1 Slope
Ignore elastic settlements when consolidation occures
Apply Rb in 3rd term of Hansen formula
Close
Save

For strip and pad footings, Peysanj calculates both shear failure and settlement criteria for a range of footing width (B1 to B2). At each footing size, the allowable bearing based on shear failure ($\sigma 1$) is calculated. For settlement control, stress is increased from zero to $\sigma 1$ with $\Delta\sigma$ increments and at each step settlement is calculated and compared with the allowable settlement set by user. Once the settlement has met the criterion, this stress ($\sigma 2$) is recorded as the allowable stress based on settlement.



Then σ1 and σ2 are compared at each footing size, and minimum of these two values is introduced as allowable bearing capacity.

For spread (mat) foundations, however, due to relatively larger footing size, shear failure will not be a limiting criterion. Therefore settlement of the footing is calculated and plotted versus stress. This stress can be set to vary from σ1 to σ2 with δσ increment. The following sections describe how this procedure can be configured by user:

Strip / Pad Footing:

From: the minimum footing width (B1) used for bearing capacity and settlement calculation

To: the maximum footing width (B2) used for bearing capacity and settlement calculation

Δ: the width step used for calculation

Δσ: the stress increment used for calculation

Excel L/B: a list of maximum 5 L/B ratios for which bearing capacity charts are exported to Microsoft Excel

Spread Footing:

σ1: the minimum stress for which settlement of foundation is calculated

σ2: the maximum stress for which settlement of foundation is calculated

Δσ: the stress increment used for calculation

Calculation Methods:

Shear Failure: Peysanj calculates bearing capacity of the footings based on Hansen equations.

Elastic: Three methods can be chosen for elastic (immediate) settlement calculation of footings. For further reference and detailed description of each methodology please refer to reference books.

Consolidation: for the purpose of calculating 1-D Terzaghi consolidation settlement, stress increase dP is calculated at the top, middle and the bottom of the layer and an average is calculated

$\delta P_{ave}=(\delta p_t+4\delta P_m+\delta P_b)/6$

Settings:

If "Goodier and Timoshenko" method is chosen for elastic settlement calculation, then stress influence depth H should be calculated first. In this section user can choose how H is calculated. Usually H is taken as the depth in which δP is reached X percent of the stress below footing, where X can be set by user.

Stress Distribution Methods:

User can set the stress distribution methods for calculation of elastic and consolidation settlements.

Ignore Elastic Settle.... : If this options is selected by user, during the calculation of total settlement of the footing, if consolidation settlement is present for a layer, the elastic settlement will be ignored in that layer. In general, the total settlement is defined as below in Peysanj software:

$$\mathbf{S = I_r\,(S_e+\alpha.S_c)}$$

where:

Ir : Rigidity factor (between zero and one; usually more than 0.9). The idea is to allow a rigid foundation to decrease the total settlement due to its ability to uniformly spread the stress.

Se : Elastic settlement

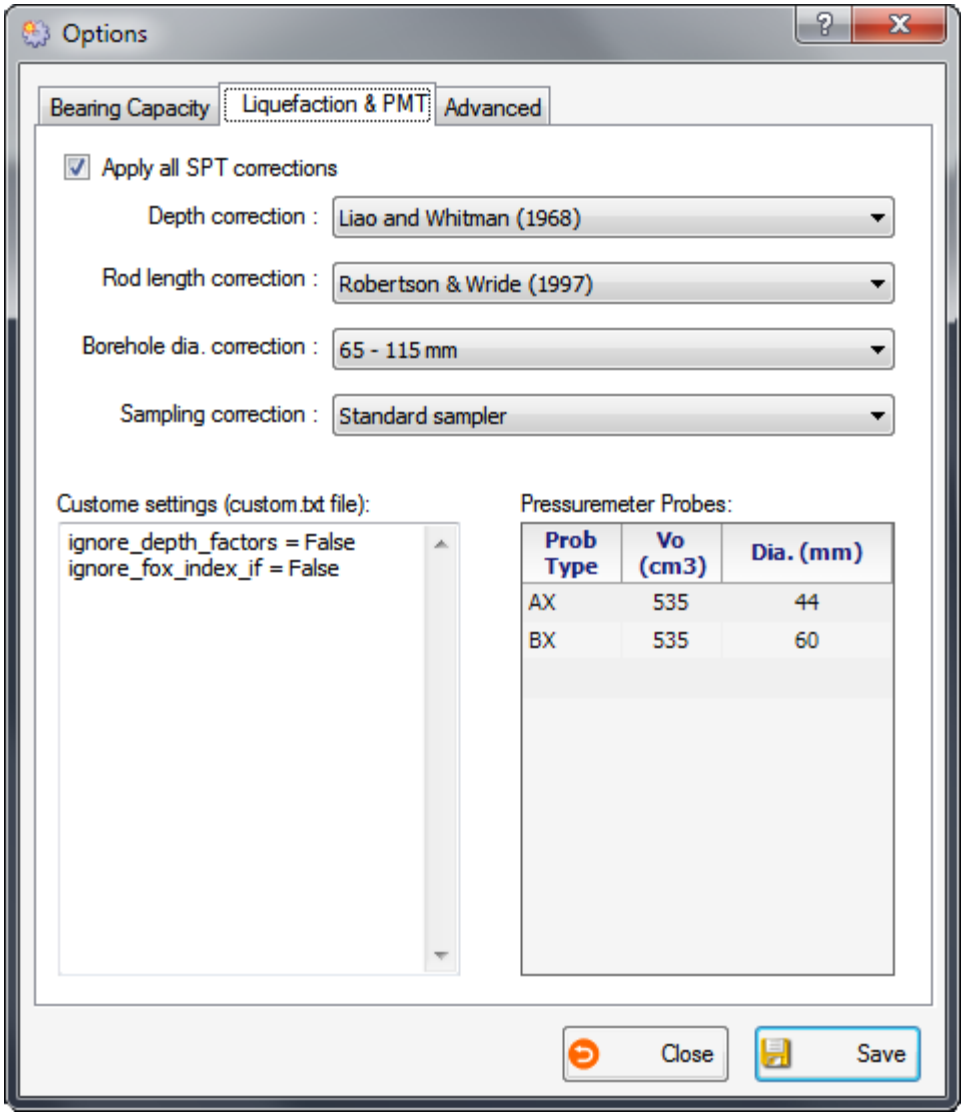
Sc: Consolidation settlement

α: User can specify what percentage of consolidation settlement should be considered in the total settlement calculation. The default value is 1. However, user can choose a lower value if the layer is not saturated to account for lower moisture contents in clay/silt layer.

Apply Rb in 3rd term.... : If this option is selected selected **Rb = 1 - 0.25 Log(0.5B)** will be applied to the 3rd term of Hansen bearing capacity formula.

Liquefaction & PMT tab

This tab allows user defining the analysis methods used for the calculation of liquefaction and pressure-meter test.



Apply All SPT Corrections:

If selected by user, SPT blow counts will be corrects during soil liquefaction analysis based on user's settings. It is assumed that N60 numbers are entered by user.

Pressure-meter Probes:

Here is a list of default probes used for pressure-meter test. User can expand this list by adding more probes to the list.

Custom Settings:

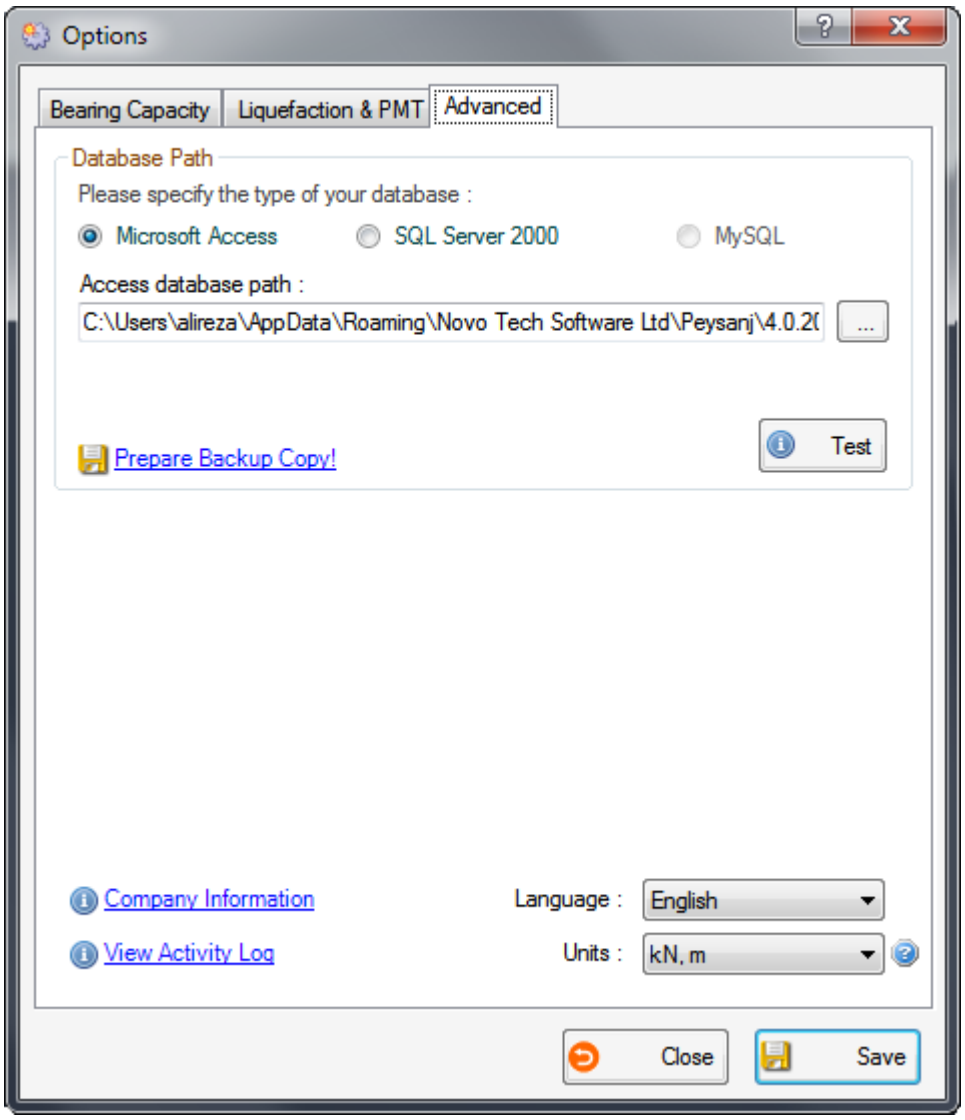
Although not every user may use this feature, it is possible to edit **custom.txt** file (copied in the Peysanj installation folder) and change the value of these two parameters:

ignore_depth_factors : If set to True, all depth factors will be considered =1 during bearing capacity analysis.

ignore_fox_index_if : If set to True, the Fox factor (I_f) used for reduction of settlement in Goodier & Timoshenko method, will be assumed =1 during settlement analysis.

Advanced tab

This tab allows user to configure and prepare backup from Peysanj database file, as well as choosing the user-interface language and units.



Database Path:

Peysanj database file is a Microsoft Access file stored in the path shown by "Access database path". The database file (**PEYSANJ4.MDB**) contains all your projects information and calculations. So, it is very important to prepare periodic backup from your database.

How to prepare a backup? Click on "Prepare Backup Copy" link and specify the location on your hard drive where you want the backup file (**PEYSANJ4.MDB**) to be copied. When the backup file is prepared, simply copy it to your flash drive, burn on CD, etc. and keep in a safe place.

How to restore a database? if you want to restore a database, click on **...** button next to the path, and select the database file. This will replace the existing database.

Company Information:

This allows user to select company logo, enter address and company name. This information is used in the reports.

View Activity Log:

This will show a list of Peysanj users activities such as Save, Delete, Print, etc. during working with the program.

Language:

Currently only English and Farsi are available. Select your language and re-run the program for this setting to take effect.

Units:

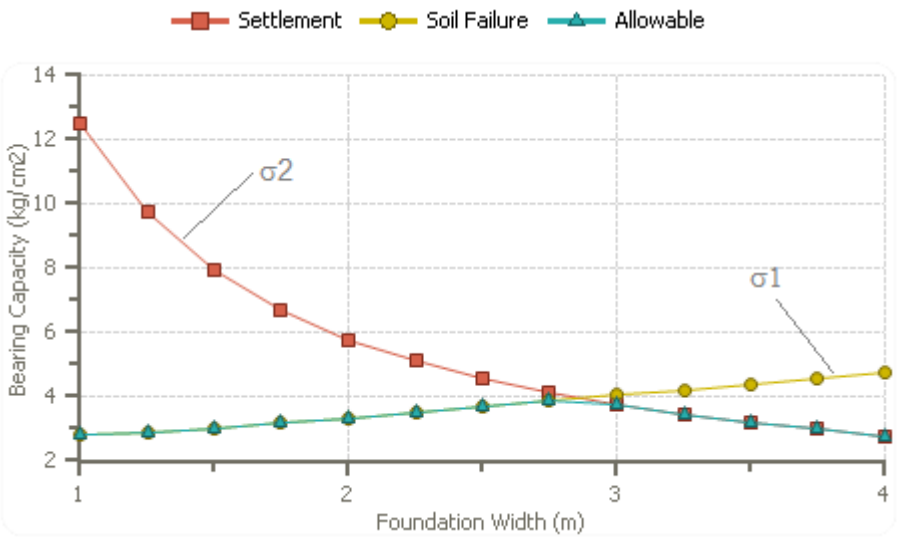
Three unit systems are available in Peysanj. Select your units and re-run the program for this setting to take effect.

How to use the main toolbar(See 3.4)
Working with graphs(See 3.4)
Print preview page features(See 3.8)

4. Theory

4.1 Bearing Capacity

For strip and pad footings, Peysanj calculates both shear failure and settlement criteria for a range of footing width (B1 to B2). At each footing size, the allowable bearing based on shear failure ($\sigma 1$) is calculated. For settlement control, stress is increased from zero to $\sigma 1$ with $\Delta\sigma$ increments and at each step settlement is calculated and compared with the allowable settlement set by user. Once the settlement has met the criterion, this stress ($\sigma 2$) is recorded as the allowable stress based on settlement.



Then $\sigma 1$ and $\sigma 2$ are compared at each footing size, and minimum of these two values is introduced as allowable bearing capacity.

For spread (mat) foundations, however, due to relatively larger footing size, shear failure will not be a limiting criterion. Therefore settlement of the footing is calculated and plotted versus stress. This stress can be set to vary from $\sigma 1$ to $\sigma 2$ with $\delta\sigma$ increment. This procedure can be configured by user through Options page(See 3.10). Peysanj performs bearing capacity analysis of the footings based on Hansen equations. Three methods can be chosen for elastic (immediate) settlement calculation of footings. For further reference and detailed description of each methodology please refer to reference books. For the purpose of calculating 1-D Terzaghi consolidation settlement, stress increase dP is calculated at the top, middle and the bottom of the layer and an average is calculated

$\delta P_{ave}=(\delta p_t+4\delta P_m+\delta P_b)/6$

If "Goodier and Timoshenko" method is chosen for elastic settlement calculation, then stress influence depth H should be calculated first. In this section user can choose how H is calculated. Usually H is taken as the depth in which δP is reached X percent of the stress below footing, where X can be set by user. In general, the total settlement is defined as below in Peysanj software:

$$\mathbf{S = I_r (S_e + \alpha . S_c)}$$

where:

Ir : Rigidity factor (between zero and one; usually more than 0.9). The idea is to allow a rigid foundation to decrease the total settlement due to its ability to uniformly spread the stress.

Se : Elastic settlement

Sc: Consolidation settlement

α: User can specify what percentage of consolidation settlement should be considered in the total settlement calculation. The default value is 1. However, user can choose a lower value if the layer is not saturated to account for lower moisture contents in clay/silt layer.

How to use the main toolbar(See 3.4)
Working with graphs(See 3.4)
Print preview page features(See 3.8)

4.2 Soi Liquefaction

4.2.1 Introduction

Soil liquefaction and related ground failures are commonly associated with large earthquakes. In common usage, liquefaction refers to the loss of strength in saturated, cohesion-less soils due to the build-up of pore water pressures during dynamic loading. Sladen et al. (1985) defined liquefaction as:

> **"**Liquefaction is a phenomenon wherein a mass of soil loses a large percentage of its shear resistance, when subjected to monotonic, cyclic, or shock loading, and flows in a manner resembling a liquid until the shear stresses acting on the mass are as low as the reduced shear resistance**"**

Liquefaction Assessment

Evaluating the liquefaction resistance of soils is an important step in the engineering design of new structures and the retrofit of existing structures in earthquake-prone regions. The evaluation

procedure widely used throughout the world is termed the simplified procedure. This simplified procedure was originally developed by Seed and Idriss (1971) using blow counts from the Standard Penetration Test (SPT) correlated with a parameter representing the seismic loading on the soil, called the Cyclic Stress Ratio (CSR). This parameter is compared to Cyclic Resistance Ratio (CRR) of the soil and if it exceeds CRR, the soil is likely to be liquefied. A safety factor against liquefaction is defined as ratio of CRR to CSR:

$$\textbf{Safety Factor} = \textbf{CRR} / \textbf{CSR} * K_\sigma * K_\alpha$$

$$\textbf{CRR} = \textbf{CRR}_{7.5(ave)} * \textbf{MSF}$$

Where:

$CRR_{7.5(ave)}$:calculated cyclic resistance ratio (average of all selected methods at a desired depth) for an earthquake with M=7.5

MSF : Magnitude Scaling Factor

K_σ : overburden stress correction factor; only applied to the following analysis methods (see details(See 4.2.5.1)):

- Vancouver Task Force Report (2007)
- NCEER (1996)
- Cetin et al. (2004)
- Idriss & Boulanger (2004)

each of the above-mentioned methods has its own equation for calculating K_σ

K_α : ground slope correction (is considered 1.0 in Peysanj)

Note : This theory manual is just an introduction to methods implemented in Peysanj and does not encompass all the technical knowledge and comments needed for soil liquefaction assessment. Therefore this document shall not be used as a reference for learning how to assess liquefaction potential. Please refer to the related books and other references for more details.

Note: Recently there has been technical discussions (by Dr Boulanger and Dr Idriss, 2010) about the accuracy and reliability of Cetin et al (2004) method. Therefore it is recommended that this method is used with cautious and full understanding of its risks. To obtain the full report please contact us.

4.2.2 Cyclic Stress Ratio (CSR)

The Cyclic Stress Ratio (CSR), is given by Seed and Idriss (1971) formula:

$$CSR_{7.5} = 0.65\left(\frac{\sigma_v}{\sigma_v'}\right)\left(\frac{a_{\max}}{g}\right)(r_d)$$

Where:

$CSR_{7.5}$: the cyclic stress ratio with reference to earthquake magnitude of 7.5

σ_v : total overburden pressure at the depth considered

σ_v' : effective overburden pressure at the same depth

a_{max} : maximum horizontal acceleration at the ground surface

g : acceleration due to earth's gravity

r_d : stress reduction factor (more(See 4.2.4))

4.2.3 Magnitude Sclaing Factor (MSF)

Since the CSR and $CRR_{7.5}$ are provided for earthquake magnitude of 7.5, a Magnitude Scaling Factor should be multiplied at $CRR_{7.5}$ to adjust its value for the target earthquake magnitudes. Peysanj covers the following MSF methods:

Tokimatsu & Seed (1987)	2.5-0.2M
Idriss (NCEER 1997)	(7.5 / M) ^ 2.56

other methods (source : NCEER 1997 report):

Mag-nitude, M (1)	Seed and Idriss (1982) (2)	Idriss (3)	Ambraseys (1988) (4)	Arango (1996) (5)	(6)	Andrus and Stokoe (in press) (7)	Youd and Noble (this report) P_L<20% (8)	P_L<32% (9)	P_L<50% (10)
5.5	1.43	2.20	2.86	3.00	2.20	2.8	2.86	3.42	4.44
6.0	1.32	1.76	2.20	2.00	1.65	2.1	1.93	2.35	2.92
6.5	1.19	1.44	1.69	1.60	1.40	1.6	1.34	1.66	1.99
7.0	1.08	1.19	1.30	1.25	1.10	1.25	1.00	1.20	1.39
7.5	1.00	1.00	1.00	1.00	1.00	1.00			1.00
8.0	0.94	0.84	0.67	0.75	0.85	0.8?			0.73?
8.5	0.89	0.72	0.44			0.65 ?			0.56?

4.2.4 Stress Reduction Factor

Peysanj covers the following methods for calculating r_d:

NCEER (1997)	
r_d= 1.0 - 0.00765 Z	for z ≤ 9.15 m
r_d= 1.174 - 0.0267 Z	for 9.15 m < z ≤ 23 m
r_d= 0.744 - 0.008 Z	for 23 m < z ≤ 30 m

r_d= 0.50	for z > 30 m

Thomas F. Blake (FugroWest Inc., Ventura, California)

$$r_d = \frac{(1.000 - 0.4113z^{0.5} + 0.04052z + 0.001753z^{1.5})}{(1.000 + 0.4177z^{0.5} + 0.05729z - 0.006205z^{1.5} + 0.001210z^{2})}$$

Idriss & Boulanger (2006)

r_d = 1 - 0.015 (Z - 4)	for z > 4 m
r_d = 1	for z ≤ 4 m

Kayen et al. (1992)

r_d = 1 - 0.012 Z

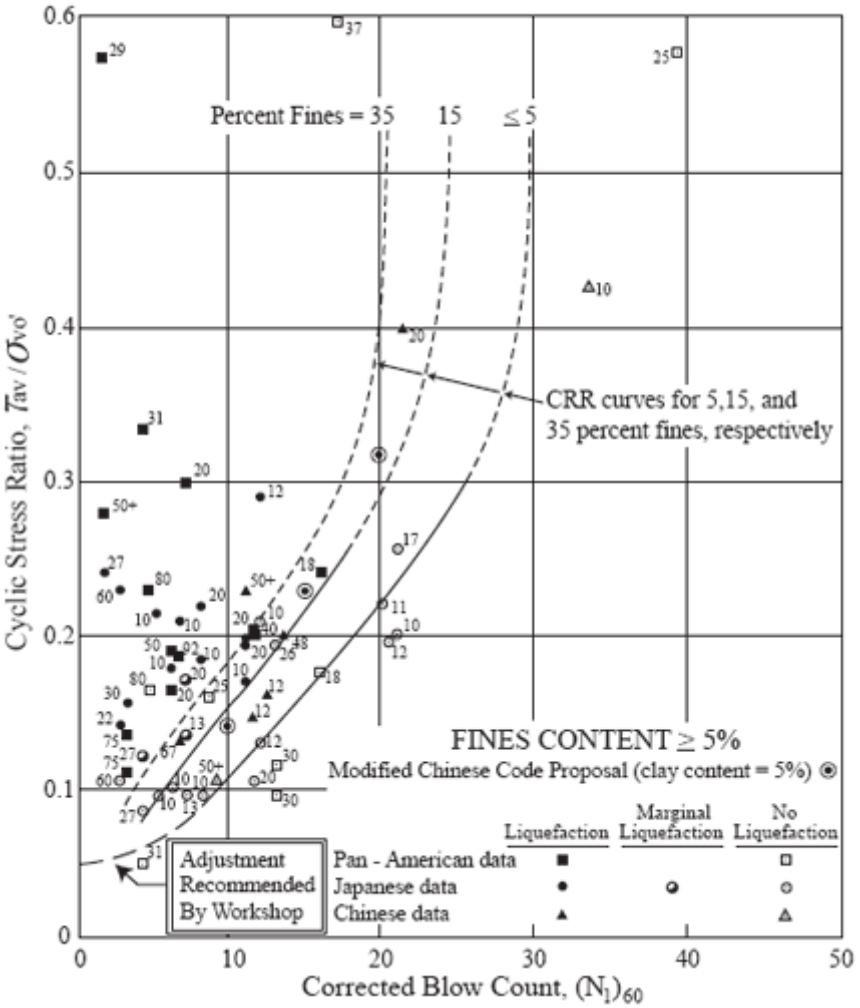
4.2.5 Cyclic Resistance Ratio (CRR)

4.2.5.1 SPT-based

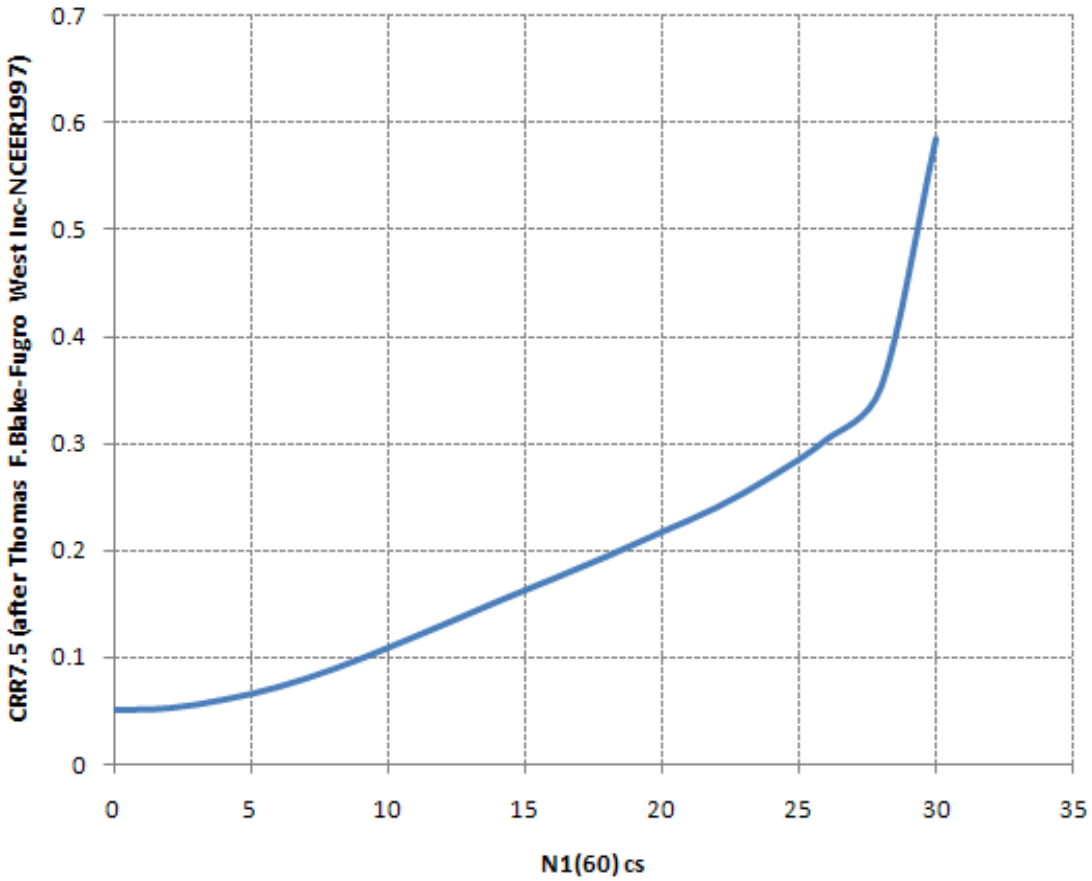
All $CRR_{7.5}$ calculation methods utilized in Peysanj are described below:

NCEER (1997) and Vancouver Task Force Report (2007)

These two methods are very similar expect that in "Vancouver Task Force Report (2007)" a K_σ parameter is multiplied in $CRR_{7.5}$. In these methodologies, $CRR_{7.5}$ is a function of depth corrected SPT blow counts $N1_{(60)}$ for clean sand (fines content less than 5 percent). For sands containing more fines content, more corrections will be applied on $N1_{(60)}$. The $CRR_{7.5}$ curve proposed by these methodologies based on $N1_{(60)}$ is shown below:



In NovoLiq, the equation proposed by Thomas F. Blake (Fugro West Inc., Ventura, California) recommended by NCEER Workshop (1997) for clean sand curve, as shown below is used. This equation is valid for $N1_{(60)cs} \leq 30$



Proposed $CRR_{7.5}$ curve for clean sand (after Thomas F. Blake - NCEER Workshop)

The K_σ factor is calculated from the following formula:

$$K_\sigma = (\sigma'_{vo} / P_a)^{f-1}$$

Where P_a is atmospheric pressure in the chosen units and f depends on relative density (Dr) and given by:

$$f = 1 - 0.005 * Dr \qquad \text{for } 40\% < Dr < 80\%$$

Dr ≤ 80% can be estimated using $Dr = 100 * S(N1_{(60)}/46)$

Boulanger and Idriss (2004)

The following equation is proposed by Boulanger and Idriss (2004) for clean sand:

$$CRR_{\sigma=1,\alpha=0} = \exp\left\{\frac{(N_1)_{60}}{14.1} + \left(\frac{(N_1)_{60}}{126}\right)^2 - \left(\frac{(N_1)_{60}}{23.6}\right)^3 + \left(\frac{(N_1)_{60}}{25.4}\right)^4 - 2.8\right\}$$

Japanese Bridge Code

This methodology is based on SPT blow counts and particle size distribution of sand.

$$0.05mm < D_{50} < 0.6mm \longrightarrow CRR_1 = 0.0882\sqrt{\frac{N_{1(60)}}{\sigma'_v + 0.7}} + 0.255\log\frac{0.35}{D_{50}} + R_3$$

$$0.6mm < D_{50} < 2mm \longrightarrow CRR_1 = 0.0882\sqrt{\frac{N_{1(60)}}{\sigma'_v + 0.7}} - 0.05$$

$$F_c < 40\% \Rightarrow R_3 = 0$$

$$F_c \geq 40\% \Rightarrow R_3 = 0.004F_c - 0.16$$

Where:
D_{50} : particle size corresponding to 50 percent passing
F_c : percent fines content passing sieve #200 (clay and silt)

Cetin et al, 2004

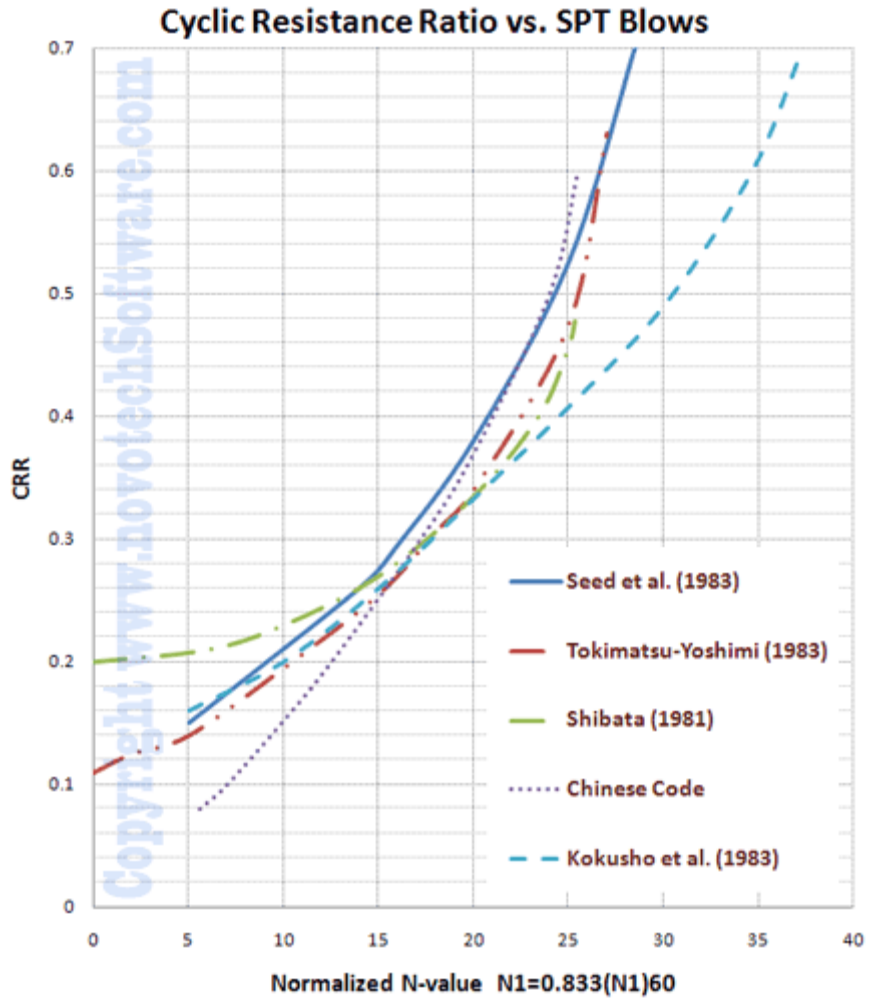
A complete explanation of this method is resented in the following paper:

> Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential
> K. Onder Cetin, M.ASCE; Raymond B. Seed, M.ASCE; Armen Der Kiureghian, M.ASCE; Kohji Tokimatsu; Leslie F. Harder Jr., M.ASCE; Robert E. Kayen, M.ASCE ; and Robert E. S. Moss, M.ASCE

Note: Recently there has been technical discussions (by Dr Boulanger and Dr Idriss, 2010) about the accuracy and reliability of Cetin et al (2004) method. Therefore it is recommended that this method is used with cautious and full understanding of its risks. To obtain the full report please contact us.

Other Methods

Some other CRR1 curves proposed by geoscientists are also implemented in **NovoLiq**. These curves are shown in the following graph; Horizontal axis is normalized corrected SPT blow counts ($N1=0.833N1_{(60)}$).



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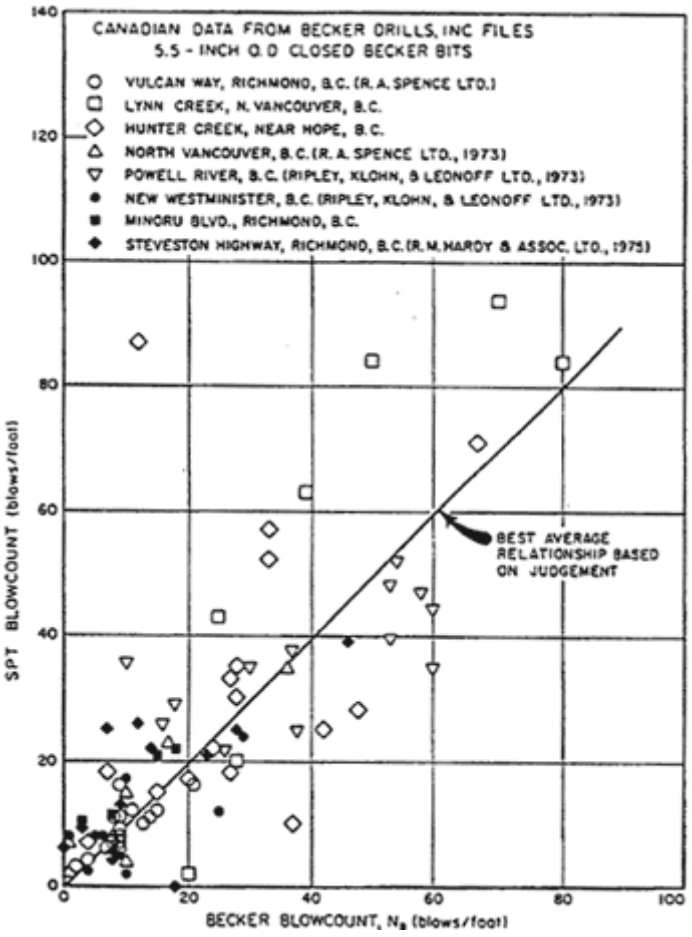
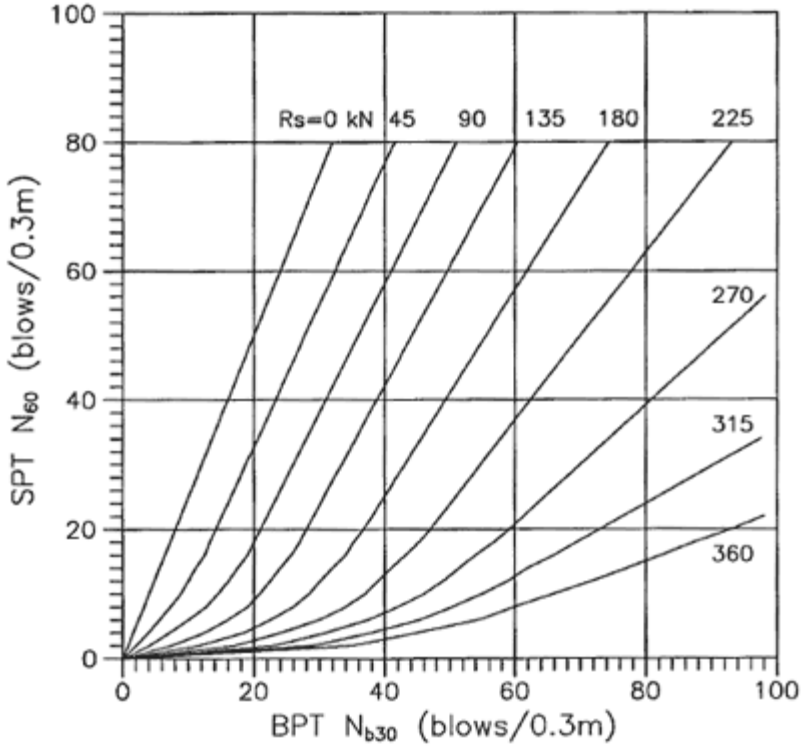
4.2.5.2 BDT-based

The approach for liquefaction assessment based on Becker Density Test (BDT) is essentially assessing the liquefaction potential, using equivalent SPT blow counts (N_{60}). Two following methods are covered in Peysanj for correlating Becker blows to SPT blows:


CANADIAN DATA FROM BECKER DRILLS, INC FILES
5.5 - INCH O.D CLOSED BECKER BITS
VULCAN WAY, RICHMOND, B.C. (R.A. SPENCE LTD.)
LYNN CREEK, N. VANCOUVER, B.C.
HUNTER CREEK, NEAR HOPE, B.C.
NORTH VANCOUVER, B.C. (R. A. SPENCE LTD., 1973)
POWELL RIVER, B.C. (RIPLEY, KLOHN, & LEONOFF LTD., 1973)
NEW WESTMINISTER, B.C. (RIPLEY, KLOHN, & LEONOFF LTD., 1973)
MINORU BLVD., RICHMOND, B.C.
STEVESTON HIGHWAY, RICHMOND, B.C. (R.M. HARDY & ASSOC. LTD., 1975)
BEST AVERAGE RELATIONSHIP BASED ON JUDGEMENT
SPT BLOWCOUNT (blows/foot)
BECKER BLOWCOUNT, N_B (blows/foot)
0
20
40
60
80
100
120
140

Harder & Seed (1986)



Sy & Campanella (1993) with considering friction (R_S)

When BDT blow counts are converted to equivalent SPT blow counts (N_{60}), the procedures for Standard Penetration Test(See 4.2.5.1) will be applied to field test data.

4.2.5.3 Vs-based

The $CRR_{7.5}$ based on V_S is calculated based on the following methodology (source: NCEER Workshop 1997 report):

Recommended Method by NCEER, 1997

Robertson et al. (1992) proposed a stress-based liquefaction assessment procedure using field performance data from sites in the Imperial Valley, California. These investigators normalized V_S by:

$$V_{S1} = V_S(P_a/\sigma'_{vo})^{0.25}$$

where P_a is a reference stress of 100 kPa, approximately atmospheric pressure, and σ'_{vo} is effective overburden pressure in kPa. **Robertson et al., 1992** suggested the liquefaction resistance bound (CRR curve) for magnitude 7.5 earthquakes, plotted in the following figure along with several sites where liquefaction did or did not occur. Subsequent liquefaction resistance boundaries proposed by **Kayen et al., 1992** and **Lodge, 1994** for magnitude 7 earthquake are also shown.

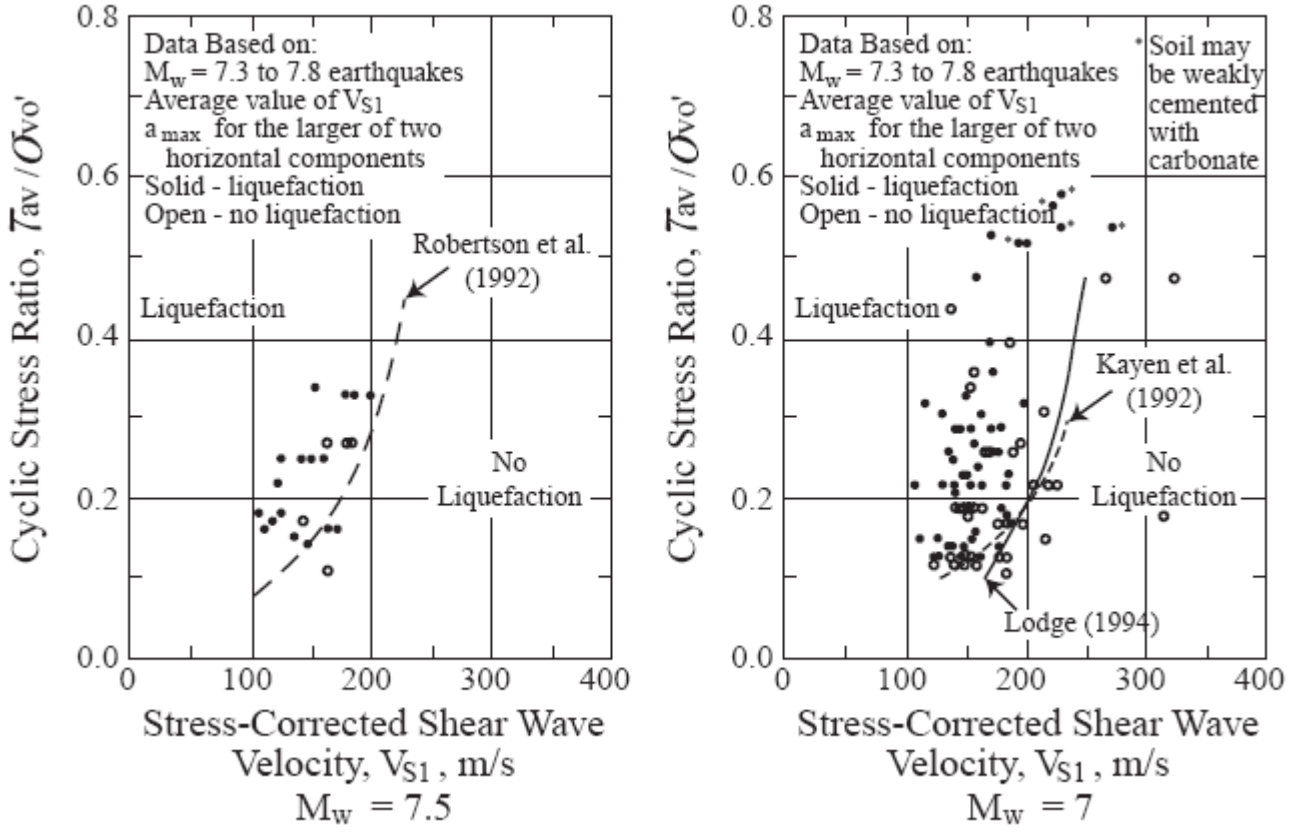

Data Based on:
Mw = 7.3 to 7.8 earthquakes
Average value of VS1
a max for the larger of two horizontal components
Solid - liquefaction
Open - no liquefaction
Robertson et al. (1992)
Liquefaction
No Liquefaction
Cyclic Stress Ratio, τav /σvo'
Stress-Corrected Shear Wave Velocity, VS1 , m/s
Mw = 7.5
Soil may be weakly cemented with carbonate
Kayen et al. (1992)
Lodge (1994)
Mw = 7

Figure 1 : Proposed cyclic stress ratio based on shear wave velocity.

The relationship proposed by **Lodge (1994)** provides a conservative lower boundary for liquefaction case histories with V_{S1} less than about 200 m/s. The relationship by **Robertson et al. (1992)** is the least conservative of the three. Professor **Ricardo Dobry** suggested a relationship between cyclic resistance ratio and V_{S1} for constant average cyclic shear strain; This formula supports a CRR bound passing through the origin and provides a rational approach for extrapolating beyond the limits of the available field performance data, at least for lower values of V_{S1} ($V_{S1} \leq 125$ m/s).

For higher values of V_{S1} , **Andrus and Stokoe** reason that the CRR bound should become

asymptotic to some limiting V_{S1} value. This limit is caused by the tendency of dense granular soils to exhibit dilative behavior at large strains. Thus, equation is modified to:

$$\tau_{av}/\sigma'_{vo} = CRR = a(V_{S1}/100)^2 + b/(V_{S1c} - V_{S1}) - b/V_{S1c}$$

where V_{S1c} is the critical value of V_{S1} which separates contractive and dilative behavior, and a and b are curve fitting parameters. Using the relationship between V_{S1} and CRR expressed by this equation , **Andrus and Stokoe** drew curves to separate data from sites where liquefaction effects were and were not observed. Best fit values for the constants a and b were 0.03 and 0.9, respectively, for magnitude 7.5 earthquakes. **Andrus and Stokoe** also determined the following best-fit values for V_{S1c} :

V_{S1c} = 220 m/s for sands and gravels with fines contents less than **5 %**
V_{S1c} = 210 m/s for sands and gravels with fines contents of about **20 %**
V_{S1c} = 200 m/s for sands and gravels with fines contents greater than **35 %**

Figure 2 presents CRR boundaries recommended by **Andrus and Stokoe** for magnitude 7.5 earthquakes and un-cemented Holocene-age soils with various fines contents. Although these boundaries pass through the origin, natural alluvial sandy soils with shallow water tables rarely have corrected shear wave velocities less than 100 m/s, even near ground surface. For a V_{S1} of 100 m/s and a magnitude 7.5 earthquake, the calculated CRR is 0.03

This minimal CRR value is generally consistent with intercept CRR values for the CPT and SPT procedures.

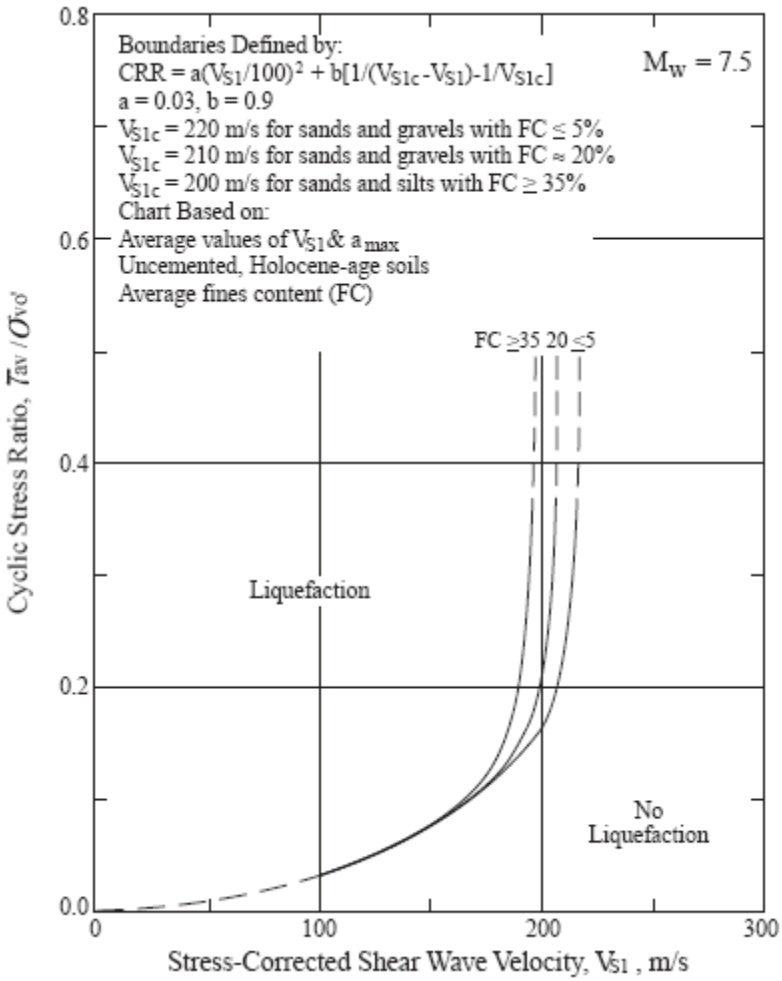


Figure 2 : Proposed cyclic stress ratio curves for different fines content (FC).

4.2.6 Post Liquefaction Movements

4.2.6.1 Lateral Spreading

The following method of estimating the post-liquefaction lateral displacements is incorporated into Peysanj:

Zhang, Robertson and Brachman, 2004

This method is essentially based on estimating maximum cyclic shear strain of each layer during and after liquefaction which is estimated from safety factor against soil liquefaction (FS) and relative density of soil (Dr), when Dr itself can be correlated from SPT or equivalent SPT blow counts.

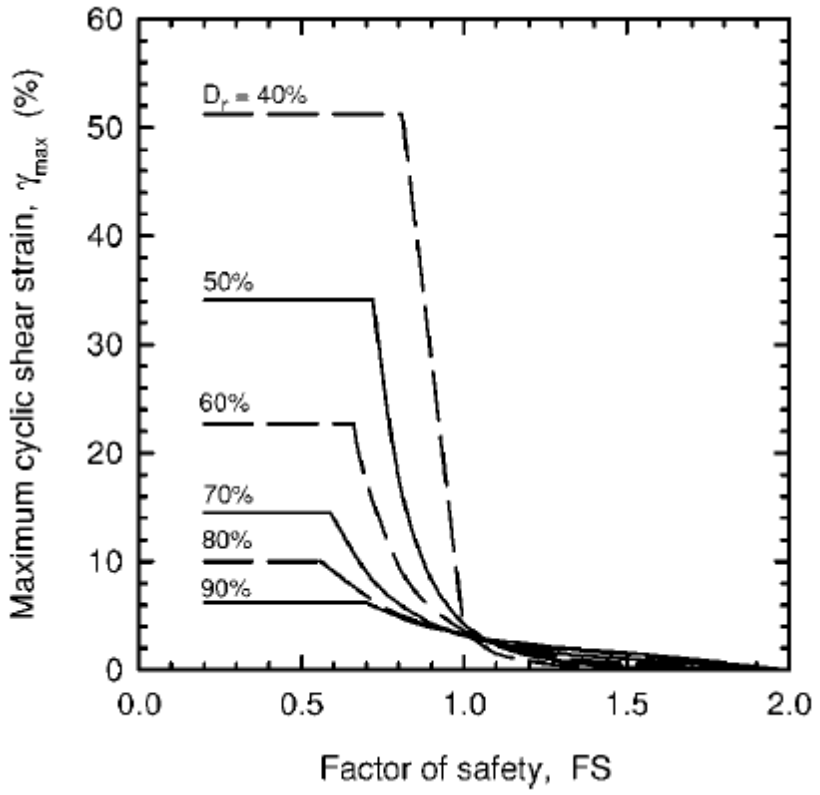


Figure 1 : maximum cyclic shear strain for post liquefaction
lateral displacement proposed by Zhang, Robertson and Brachman, 2004.

Then, the Lateral Displacement Index (LDI) is calculated from the following equation:

$$\mathrm{LDI} = \int_0^{z_{\max}} \gamma_{\max} dz$$

and according to site sloping conditions (**Gently Sloped** / **Free Face)** the lateral displacement is estimated. To read the complete procedure proposed by the authors, please read the following paper from our website:

Estimating Liquefaction-Induced Lateral Displacements Using the Standard Penetration Test or Cone Penetration Test
G. Zhang; P. K. Robertson; and R. W. I. Brachman

4.2.6.2 Reconsolidation Settlement

Post-liquefaction settlements occur during and after earthquake shaking. For level ground conditions the amount can be computed from the volumetric reconsolidation strains induced as the excess pore water pressures dissipate. Based on field experience during past earthquakes, the amount of volumetric strain depends on penetration resistance and the CSR applied by the design earthquake. Curves proposed by Ishihara and Yoshimine (1992) are shown in Figure 1 and indicate that volumetric reconsolidation strains can range between about 4.5% for very loose sand

to 1% for very dense sands. These curves are recommended for estimating post-liquefaction settlements.

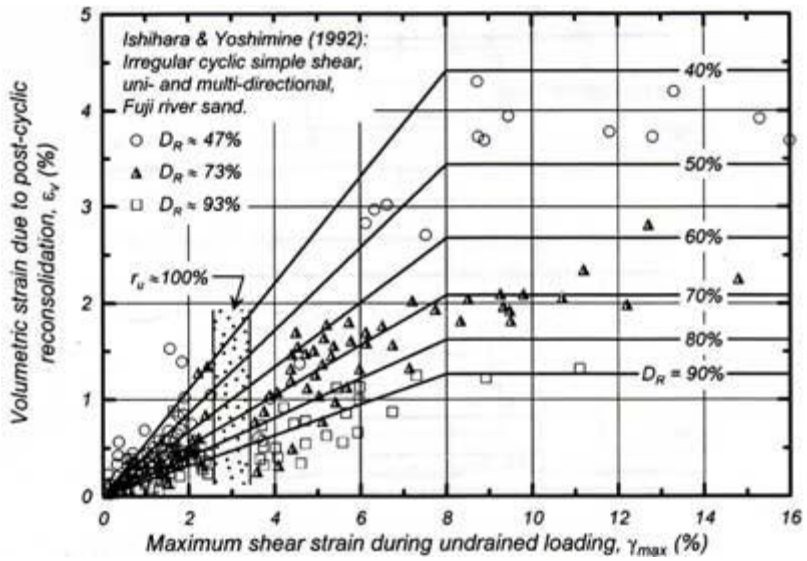


Figure 1 : Recommended relationships for volumetric reconsolidation strains as a function of maximum shear strain and relative density (Ishihara & Yoshimine 1992)

5. Online Resources

5.1 Novo Tech Website

http://www.novotechsoftware.com

5.2 PEYSANJ Updates

http://www.novotechsoftware.com/updatelogs/peysanj.txt

5.3 Other Programs

http://www.novotechsoftware.com/products/

5.4 Contact Us

http://www.novotechsoftware.com/contact-us/